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DEVELOPMENT OF SOFTWARE BASED WATER INFLUX MODEL BY USING COMPUTER PROGRAMMING LANGUAGE

Bathula Sai Mutya Naveen
Student
Dr. R. Giri Prasad
Associate professor and Head of the department
Petroleum engineering
Aditya engineering college
Surampalem

Abstract:

Quest to explore and extract hydrocarbons is getting more and more challenging and technology intensive as we move deeper and look forward to a variety of geologies. In such a scenario it is essential to understand the fundamentals of reservoir engineering as well as possible and as early as possible for a student.A variety of industrial software are available for field development and management, which are very costly and sometimes unavailable for a student to learn. Commercial software is proprietary and has its own operating workflow. However, looking closely atthem, we realize that there are few common fundamental concepts that serve as pillars, irrespective of any software.So, I believe that a gap exists between academic level; where students know the equations, but rarely know its applications in real life scenarios and industry; that have software-based applications to provide solutions but it takes one a while to learn them. Tobridge this gap, the idea is to address such fundamentals such as MBE and simulation through open source software, which will allow the studento experiment and learn, and teachers to explain better. Also they can be used for small scale field calculation and datavalidation. I will be using **MACROS** and **PYTHON** to develop such a tool. Tool will be flexible enough to encourage students to input their own ideas and code. This will be the objective of the study.

Introduction:

In reservoirs all hydrocarbons are surrounded by water bearing stones called aquifers. all aquifersmay be heavier than oil or gas reservoirs they connect as to occur unbounded in size or they may be as poor in size as to be negligible in their effect on reservoir performance. As pressure loss during pressure deficiency, the solid waters within the aquifers increase and overrun into the crude oil reservoirs. The threatening water helps to run the oil to the generating wells, primary toenhanced oil recoveries. Such as water influx also moves to moderate the pressure drop. The degree related to water influx enhanced oil recovery calculate on the size of the connecting aquifer, the degree of connection between the aquifer and crude oil reservoir, and basically the load of water that crashes into the reservoir. Various gas and oil reservoirs formed by a system termed water drive. Generally this is called a natural water drive to determine it from other artificial water drives that connect the injection of water into the formation. Hydrocarbon formulation from the reservoir and the following pressuredrop instant a response from the aquifer to balance the pressure drop. This response comes in a system of water influx, generally called water invasion, which is related to:

- Development of water in the aquifer

- Compressibility of the aquifer rock

Based on the term of the reservoir pressure maintenance controlled by the aquifer, thenatural water drive is generally stated as:

- Active water drive
- Partial water drive
- Limited water drive

The term active water drives is assigned to the water invasion system in which the rate of water influx is parallel to the reservoir total production rate. Active water-drive reservoirs are generally defined by a regular and easy pressure drop. The aquifer can be arranged as infinite or finite. Geologically all production is finite, but may act as infinite if the changes in the pressure at the oil water influence are not "noticed" at the aquifer terminal. In familiar, the outer terminal control the behaviour of the aquifer and, therefore:
A. Infinite system illustrates that the consequence of the pressure turn at the oil/aquifer terminal can never be noticed at the outer terminal. This terminal is for all points at a constant pressure equal to initial reservoir pressure.
B. Finite system illustrates that the aquifer over limit is damaged by the influx into the oil zone and that the pressure at this overr limit turn with time.
It is important to guide the producing wells exactly and to reduce water production. Reducing water production in "Edgewater drives" must require regularly shutting side wells once the advancing water is collected. Reducing water production in "bottom water drives" must require regular cementing in lower perforation as the bottom water gradually rises. The reservoir supervision for water drives is an active determination program. The first stage of characteristic numerical models that finally assume the aquifer, mainly its output. This stage covers accurately estimating aquifer model limits. The last stage covers connecting aquifer and reservoir models into a simple model that can be used to plan future recovery and to find maximum depletion systems. The success of the last stage depends heavily on the success of the first stage. Water influx models are numerical models that assume and predict aquifer performance. Mainly they predict the cumulative water influx history. When successfully combined with a reservoir simulator, the final product is a model that finally simulates performance of water drive reservoirs.

WHAT IS PYTHON:

Python is an object-oriented and interpreted language that's easy to use, and runs on manyoperating systems including windows, Mac OS, Linux and More.It's named after the cult comedy show Monty python's flying circus(not after the snake) by Guido VanRussum and you will find various references to many python sketches in the several documents related to python. Python supports basic data types such as numbers and strings as well as more complex types like lists and dictionaries that can greatly simplify data processing. python also supports several programming paradigms and can be used for procedural programming, functional programming and Object oriented programming.

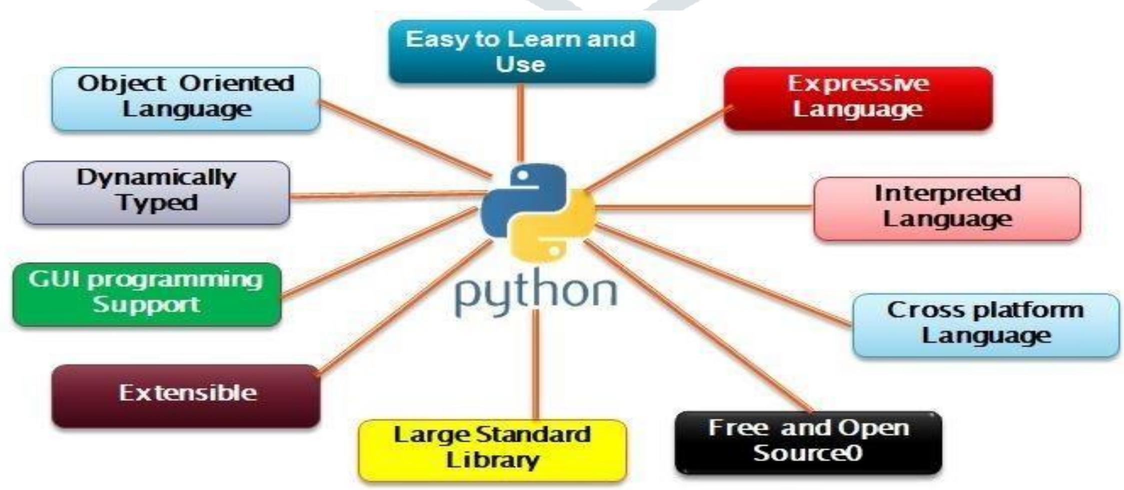

Fig 1 - Features of python

BASIC PROGRAMME IN PYTHON:

Code:
Print("Hello world!")
Output:
Hello world!
When you called a function in python, you provide the things you want to print inside parenthesis, so we have provided a string literal, Hello World! And that's what got printed. A string literal is character is a sequence of characters any thing you can type in the keyboard basically enclosed in quotes, you can use a single Quote or Double Quotes to enclose a string ,we have to use same quotes in the two ends. The string literal "Hello world!" is called an argument, we are passed the argument to the print function. In the one print function you are able to give arguments as much as you want. print("The end", "is it?" , "Keep study to learn more", 4). In the end of each argument we need to give the comma and at the end we didn't give the under " " because it is numerical

PYTHON OPERATORS:

Python divides the operators in the following groups:

- Arithmetic operators
- Assignment operators
- Comparison operators
- Logical operators
- Identity operators
- Membership operators

THE STEADY STATE:

The flow regime is identified as a steady-state flow if the pressure at every location in the reservoir remains constant, i.e., does not change with time. Mathematically, this condition is expressed as:

$$(\partial p / \partial t)\, i = 0$$

The above equation states that the rate of change of pressure p with respect to time t at any location i is zero. In reservoirs, the steady-state flow condition can only occur when the reservoiris completely recharged and supported by strong aquifer or pressure maintenance operations.

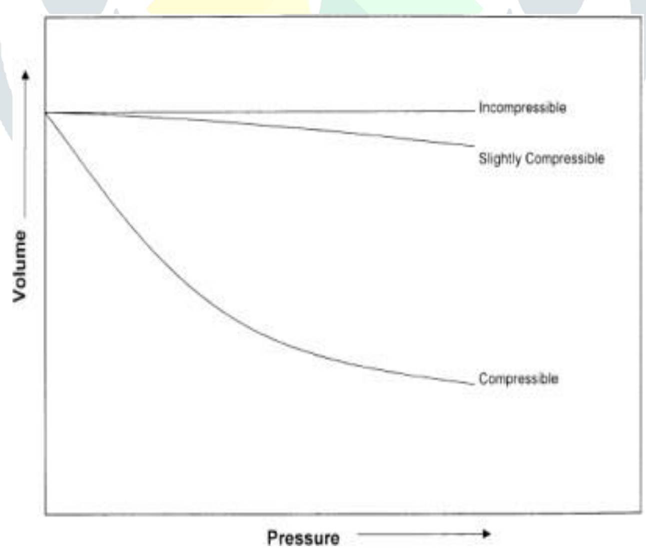

Fig 2 - Actual behaviour of pressure with time

THE UNSTEADY STATE WATER INFLUX MODEL:

The unsteady-state flow(frequently called transient flow) is defined as the fluid flowing condition at which the rate of change of pressure with respect to time at any position in the reservoir is not zero or constant.

$$(\frac{dp}{dt})_i = f(i,t)$$

Van Everdingen-Hurst Unsteady-State Model

When an oil well is brought on production at a constant flow rate after a shut-in period, the pressure behavior is essentially controlled by the transient (unsteady-state) flowing condition. This flowing condition is defined as the time period during which the boundary has no effect on the pressure behaviour. In a dimensionless form, the diffusivity equation takes the form:

$$\frac{\partial^2 P_D}{\partial r_D^2} + \frac{1}{r_D}\frac{\partial P_D}{\partial r_D} = \frac{\partial P_D}{\partial t_D}$$

Van Everdingen and Hurst solved the diffusivity equation for the aquifer-reservoir system by applying the Laplace transformation to the equation. The authors' solution can be used to determine the water influx in the following systems:

- Edge-water-drive system (radial system)
- Bottom-water-drive system
- Linear-water-drive system

Edge-Water Drive:

Van Everdingen and Hurst expressed their mathematical relationship for calculating the water influx in a form of a dimensionless parameter that is called *dimensionless water influx* WeD. They also expressed the dimensionless water influx as a function of the *dimensionless time* tD and *dimensionless radius* rD, thus they made the solution to the diffusivity equation generalized and applicable to any aquifer where the flow of water into the reservoir is essentially radial. The solutions were derived for cases of bounded aquifers and aquifers of infinite extent. The authors presented their solution in tabulated and graphical forms.

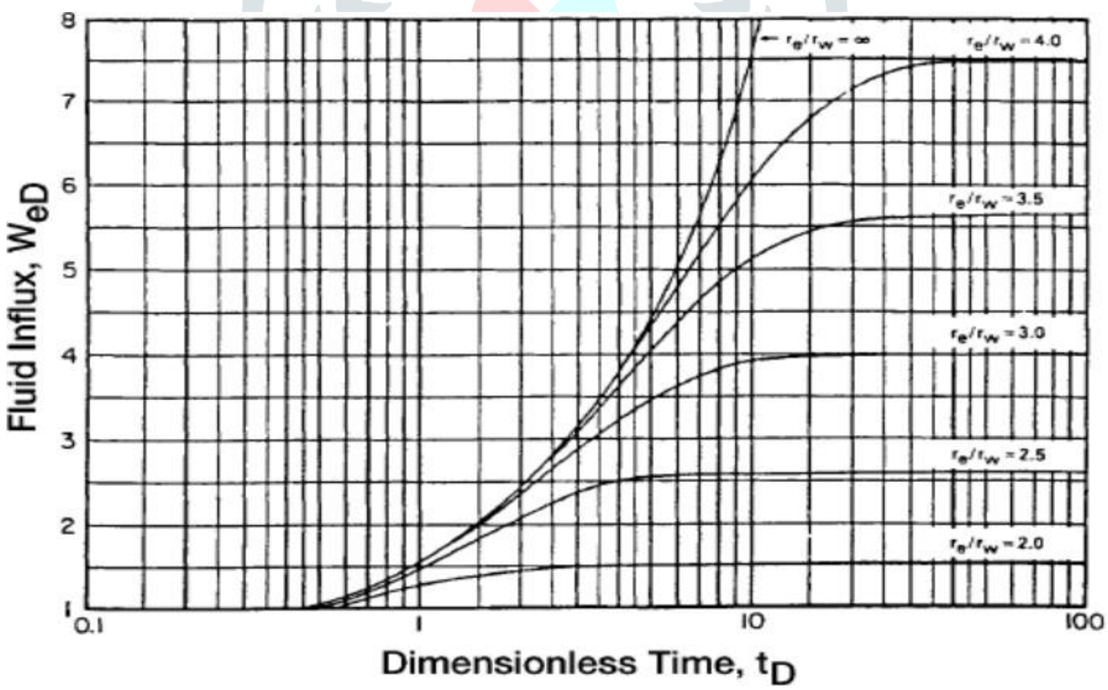

FIG 3 - DIMENSIONLESS WATER INFLUX WeD FOR SEVERAL VALUES OF re/ rR, i.e ra/re. (VAN EVERDINGEN AND HURST)

The Pipelines and Risers facility uses Subsea production wells. The typical High Pressure (HP) wellhead at the bottom right, with its Christmas tree and choke, is located on the sea bottom. A production riser (offshore) or gathering line (onshore) brings the well flow into the manifolds. As the reservoir is produced, wells may fall in pressure and become Low Pressure (LP) wells. This line may include several check valves. The choke, master and wing valves are relatively slow, therefore in case of production shutdown, pressure before the first closed sectioning valve will rise to the maximum wellhead pressure before these valves can close.

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Principle of superposition:

In order to determine the total water influx into a reservoir at any given time, it is necessary to determine the water influx as a result of each successive pressure drop that has been imposed on the reservoir and aquifer. The van Everdingen-Hurst computational steps for determining the water influx are:

Step 1. Assume that the boundary pressure has declined from its initial value of pi to p1 after t1 days. To determine the cumulative water influx in response to this first pressure drop, Δp1 = pi − p1 can be simply calculated from Equation

$We = B\ \Delta P1\ (\ WeD)1$

Where We is the cumulative water influx due to the first pressure drop Δp1. The dimensionless water influx $(WeD)t1$ is evaluated by calculating the dimensionless time at t1 days. This simple calculation step is shown in section A of Figure

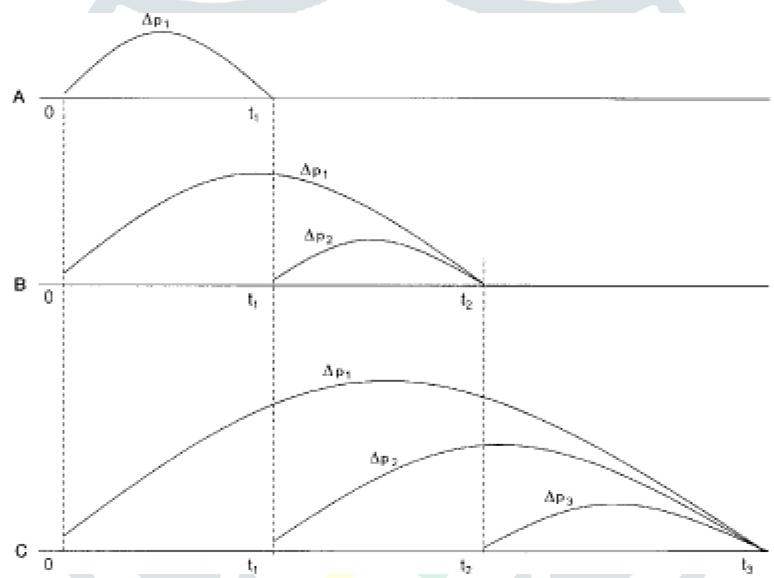


FIG 4- ILLUSTRATION OF THE SUPERPOSITION PRINCIPLE

Step 2. Let the boundary pressure decline again to p2 after t2 days with a pressure drop of Δp2 = p1 − p2. The cumulative (total) water influx after t2 days will result from the first pressure drop Δp1 and the second pressure drop Δp2, or: We = water influx due to Δp1 + water influx due to Δp2

$$We = (We)\Delta P1 + (We)\Delta P2$$

Where,

$(We)\Delta P1 = B\ \Delta P1\ (WeD)t2$

$(We)\Delta P2 = B\ \Delta P1\ (WeD)t2 - t1$

The above relationships indicate that the effect of the first pressure drop Δp1 will continue for the entire time t2, while the effect of the second pressure drop will continue only for (t2 − t1) days.

Step 3. A third pressure drop of Δp3 = p2 − p3 would cause an additional water influx as illustrated in section C of Figure . The cumulative (total) water influx can then be calculated from:

$$We = (We)\Delta P1 + (We)\Delta P2 + (We)\Delta P3$$

where,

$(We)\Delta P1 = B\ \Delta P1\ (WeD)t3$
$(We)\Delta P2 = B\ \Delta P1\ (WeD)t3{-}t1$
$(We)\Delta P3 = B\ \Delta P1\ (WeD)t3{-}\ t2$

The van Everdingen-Hurst water influx relationship can then be expressed in a more generalized form as:
$We = B \sum \Delta P\ WeD$

The authors also suggested that instead of using the entire pressure drop for the first period, a better approximation is to consider that one-half of the pressure drop, ½ ($Pi - P1$), is effective during the entire first period. For the second period, the effective pressure drop then is one-halfof the pressure drop during the first period, ½ ($Pi - P2$), which simplifies to :

$$\tfrac{1}{2}\,(Pi - P1) + \tfrac{1}{2}\,(P1 - P2) = \tfrac{1}{2}\,(Pi - P2)$$

RESULT OF MACROS PROGRAM

Van Everdingen & Hurst - Unsteady State - Infinite Aquifer - Edge Water Drive

	Reservoir	Aquifer
radius, ft	2000	Infinite
h, ft		22.75
k, md		100
pore		0.2
miu w, cp		0.8
cw, psi-1		7.00E-07
cf, psi-1		3.00E-07
Angle		360

<<< Values in yellow are changable.
<<< Values in green are resultant values.

ct, psi-1	1.00E-06
B	20.37

Days	Press, psi	tD	WeD	dP	We
0.00	2500	0	0	0	0.00
182.50	2490	180.45	69.65	5	7,092.70
365.00	2472	360.89	123.66	14	32,451.68
547.50	2444	541.34	174.00	28	92,695.65
730.00	2408	721.79	222.14	46	2,08,000.90
3650.00	2330	3608.94	894.66	85	4,90,085.91

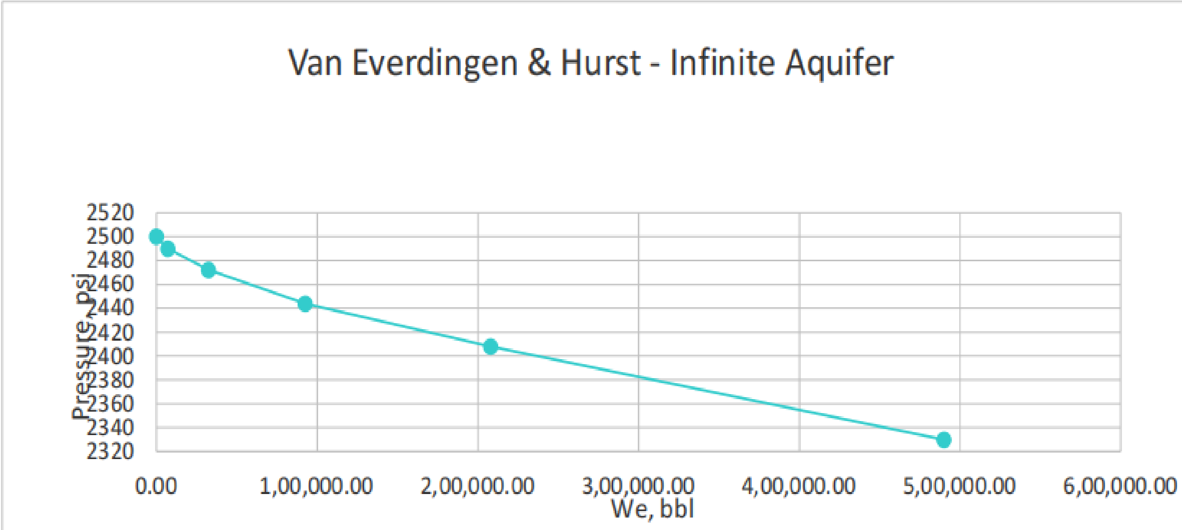
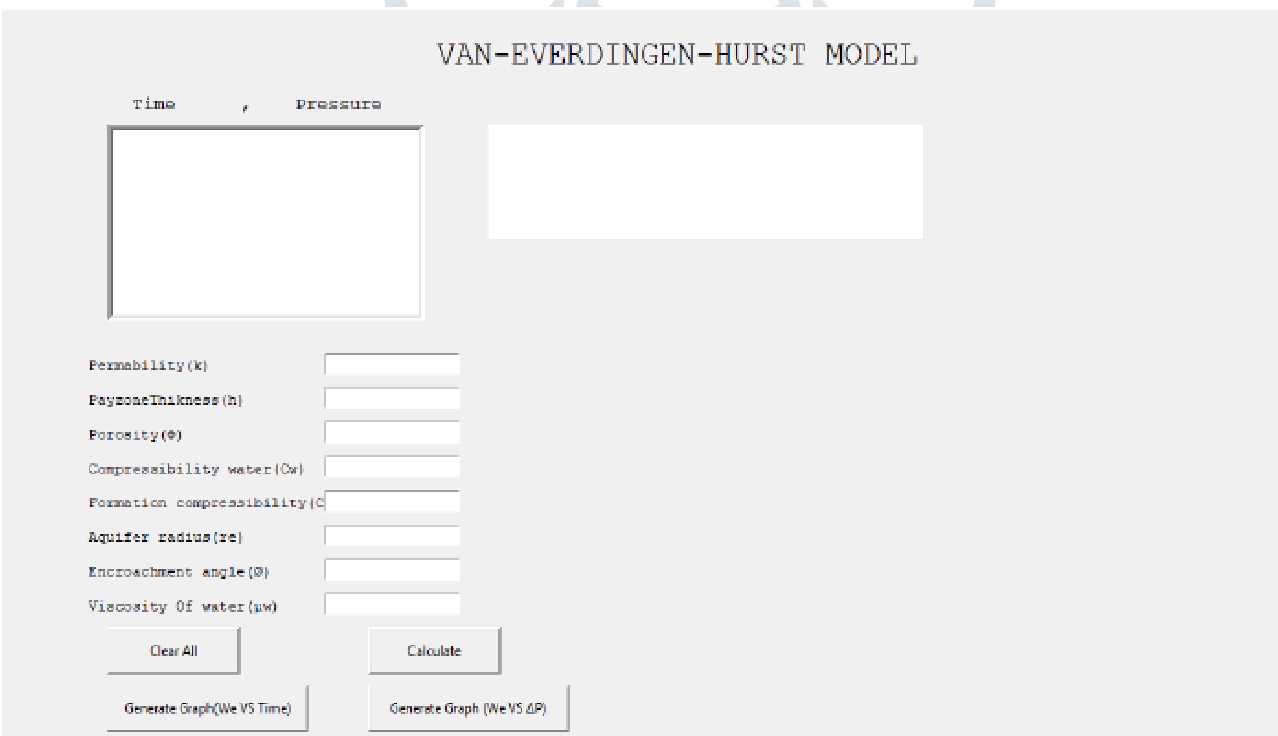
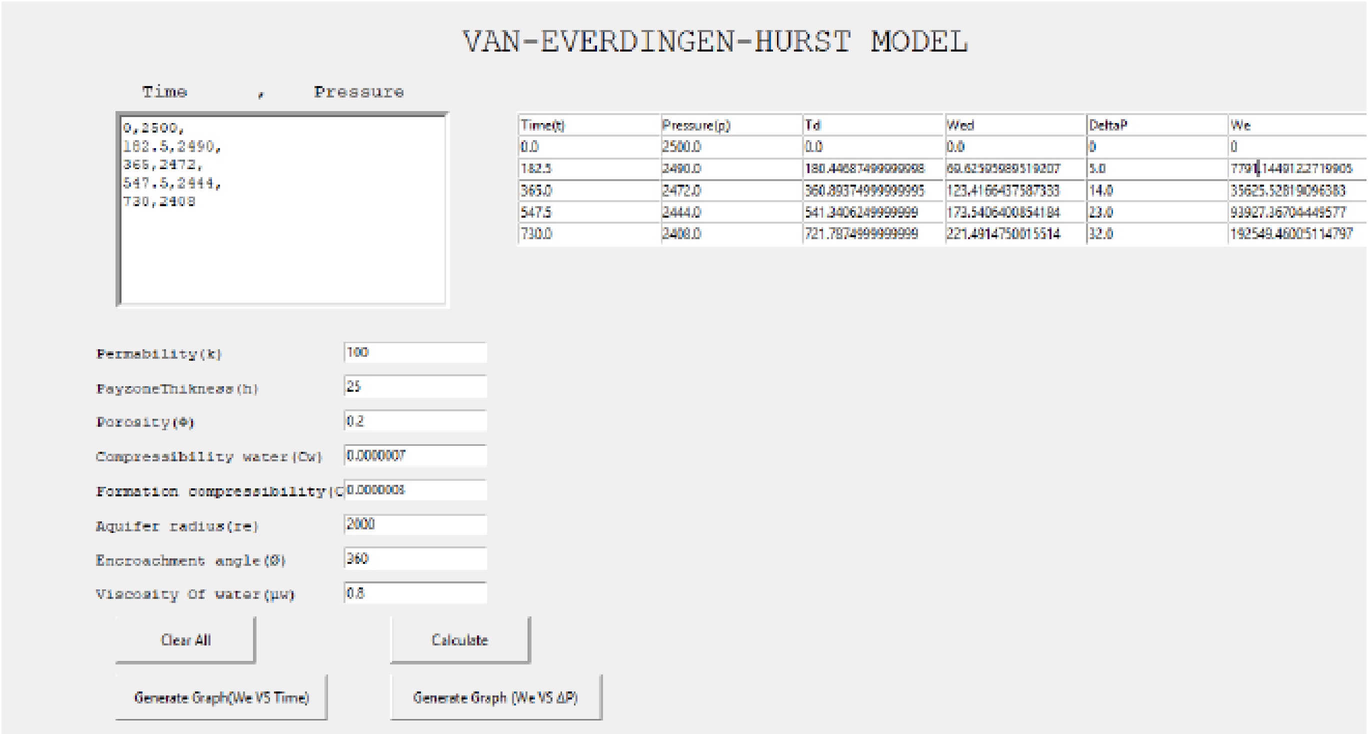


FIG 6 - VAN EVERDINGEN AND HURST - INFINITE AQUIFER, PRESSURE VS WE GRAPH

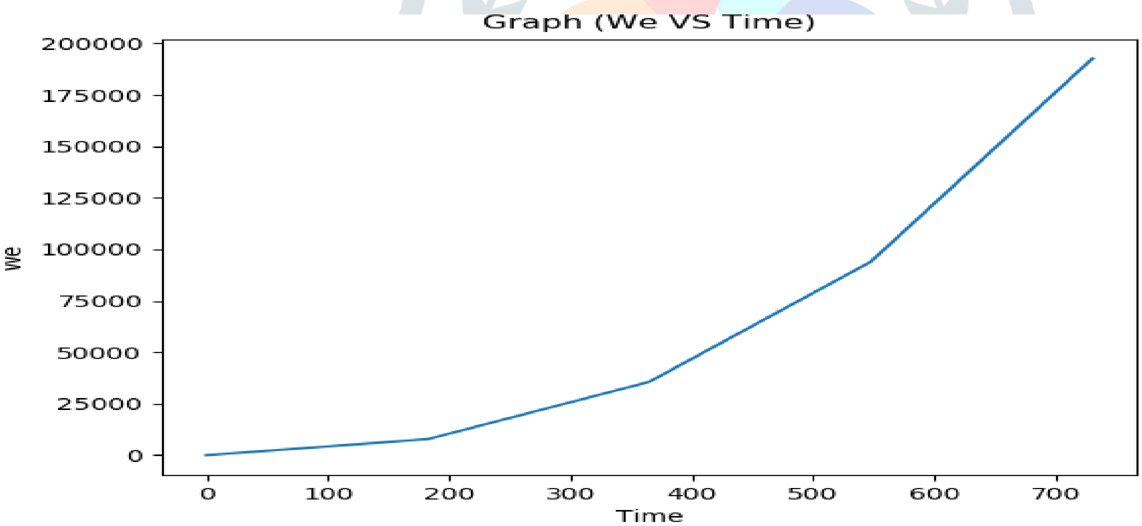
RESULT OF PYTHON PROGRAM

User Interface of python program :





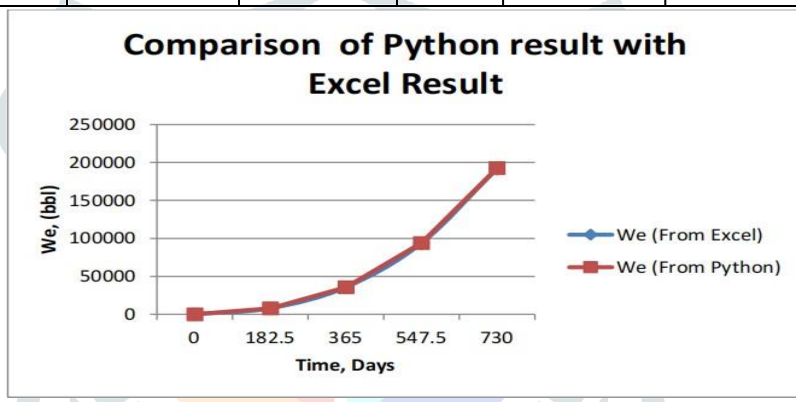
GRAPHICAL USER INTERFACE AFTER PUTTING THE VALUES IN VAN- EVERDINGEN - HURST MODEL



PYTHON PLOT OF WATER INFLUX VS TIME

Comparison of Python Van-Everdingen-Hurst water influx model with excel Model:

Time,Days	Pressure (psi)	tD	WeD	Delta P	We (From Excel)	We (from Python)
0	2500	0	0	0	0	0
182.5	2490	180.456	69.62885	5	7777.542	7791.144912
365	2472	360.912	123.4219	14	35563.34	35625.52819
547.5	2444	541.368	173.5481	23	93763.43	93927.36704
730	2408	721.824	221.501	32	192213.4	192549.4601



Conclusions:

The sole objective of the study was to provide a foundation for in-house software development related to the petroleum industry. This foundation will provide students to understand the concepts, improve the quality of human-machine interaction and quickly grasp the grip over utilization as well as development of the industry software. The objective was achieved using open source programming language PYTHON (version 2.7). All the codes are included along with the description of the relative subjects in respective chapters. These codes are the "snippets" the can be easily understood and implemented. Since we are using open source language, all the related resources are available for free. However to make sure that our programme generates the results with same accuracy as those commercial softwares (MBAL and PETREL in this case), the results were obtained for similar cases, compared and number of attempts have been made to achieve a highly accurate match. Also an attempt has been made to develop a stand-alone programme which provides GUI, handles calculation in the background and exports the results in the desired format. Hence, I can say that a solid foundation was laid on which the further modules related to simulation can be developed.

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