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Analyzing The Statistics Function For Determination Of Oil Flow Rate Equation in New Productive Zone

Ira Herawati [1,*], Novia Rita[1,*], Novrianti[1], Rosalia M Taufand[1]
[1]Petroleum Department, Faculty of Engineering, Islamic University of Riau, Riau, 28284,Indonesia

* Corresponding author : iraherawati@eng.uir.ac.id, noviarita@eng.uir.ac.id
Tel.:+81-72-867-1686; fax: +81-72-867-1658 [Tel./fax of the corresponding author]
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Abstract

Oil rate will be decline at production time in a well. So, we have to produce in another layer who assume have a potential. Before we produce another layer who assumed have a potential, we need to predict oil rate to known how much oil gain. In this field research oil rate prediction in new productive zone was determine following by analogical data and near well references. In this method there is a difference determine of oil rate for each people. Cause of that, in this research using analysis statistical for oil rate predicting in new productive zone based on linear function for Productivity Index (PI) and polynomial function for watercut. Determining equation of linear and polynomial functions for oil rate prediction measuring by production and logging data for each well who assumed productive zone in area X field RMT. Based of statistically analysis for linear function known that coefficient determination (r^2) = 0.9964 and polynomial function known that coefficient determination (r^2) = 0.9993. This result indicated that we can use both of the functions for oil rate prediction in new productive zone in area X field RMT. After that, based on both of functions calculate oil rate prediction each wells in area X field RMT. So, known differences in oil rate prediction between oil rate data in area X field Y known is 28.13 BOPD or 0.78%.

Keywords: Oil Rate, Statistical Analysis, Coefficient Determination , Productivity Index, Watercut

1. Introduction

The decline of oil flow rate in an oil field becomes a problem that have to be faced during the production period. One of several ways to solve the declining oil flow rate problem is by producing a new zone. Previously, oil flow rate determination in the new zone that have not been producing at a potential reservoir is determined from the logging data and wells near by reference (Gollan, Michael. Whitson, Curtis H,1996). This method focuses on the analogy of the existing data. By using these methods, several parameters that become the benchmark of oil flow rate estimation have an uncertainty factor. In this case, everyone has the different determination of an oil flow rate with the same parameters. It makes this research needs to be done to determine that uncertainty factor. Potential reservoir which is the becomes the object in this research shall be referred to the productive zone (Kelkar, 2002).

Productive zone in this study is the layer that has never been in produces by a well, so it becomes a backup for the well. This occurs because the well was still quite good producing from another layer or from wells that are still relatively new, so there arecertain zone that has never been produced. When production wells down then, can be done to increase production by opening new layers that are considered productive. (Ariadji, Tutuka. Radjes, 2012)

In the case of management and these issues , it is often found some forecasting activity, prediction, estimation and more. One method that can be used to solve the problem is statistical methods. The used of statistical method sare very dependent on the structure of the data or the number of variables (Stroud K.A and J. Dexter, 2003) . One of the method that is used for one variable or more than one variable is the regression analysis (Stroud K.A and J. Dexter, 2003) .

Regression analysis is a statistical methodology to predict the value of one or more response variables (*variable dependen*) from the collection of predictor variable value (*variable independen*) . This analysis can also be used to predict or forecast the effect of the predictor variable (independent variable) on the response. In regression analysis , it is learn how does these variables relate and expressed in a mathematical function.This research is done by using regression analysis, to determine the function representing the approximate flow rate of oil in the productive zone (Jothikumat, 2004).

The objective of this paper is to determine the coefficients and function of linear regression of the permeability and thickness of the perforation of the Productivity Index and regression function at the polynomial correlation to the water saturation of the Watercut. At the end we could to estimate the flow rate of the oil in the productive zone using a regression function and evaluation of oil flow rate estimates based on the function of the oil flow rate based on the data.

2. Material and Methods

Productive zone in this study is a new zone that has not been produced and has potential if seen from the data logging. This study uses data of each well log consisting of log GR (Gamma Ray), log SP (Spontaneous Potential), caliper logs, resistivity logs, neutron and density logs. Based on the GR deflection curve at minimum value, indicates that the area with the curve approaching the minimum value may be a reservoir layers because of thenonshale (permeable) rock type whichin this case, the sandstone type, the reservoir rock type in general. Mean while, if the deflection curve leads to a maximum value then the rock type may be shale (impermeable).

On the log resistivity deflectioncurve with a great value indicates the potential for hydrocarbons contained therein, on the contrary if the deflection curve with a small resistivity values indicates the potential non-hidrokarbon (water zone). From the results of neutron log that has a deflection at a great value, it can be seen that these rocks have a large porosity. In the productive reservoir layers, the neutron-density log curves will intersect and form of separation. This indicates the exist of permeable layer and a reservoir layer. This both curvesshows the formation of separation column (cross over).

The small cross over indicates the type of fluid is oil. At the gas zone, these two curves show the formation of the separation column. A large cross over, gas zone is also characterized by neutron porosity price that is far less than the price of porosity, so it would show the existence of a larger separation.

In this research, to determine the flow rate of oil in the productive zone, it would require some data from wells located in an area that is not separated by any fault (fault). A layer of sand that is used as data in this study is the same sand layer. This is done because the consideration of the physical properties of rock and fluid at the same sand tends not much different when compared to the physical properties of fluids and rocks on different sand.

In areas 1 and 3 there are 614 wells candidates which are productive zones that have been produced. However, this research is limited to areas that are not separated by their fault, so the area that it is included into non-separated by fault area is area 1with focus area 1, 2, 3 and area 3 with focus area 5 there are only 104 wells. After determining the candidate wells that are included in the areas relevant to the objectives of this study, furthermore, pick the same sand layer seen in a predetermined area. In this study, A-1 sand layer chosed.

Of the 104 wells which are reviewed there were 21 wells that have a productive zone A-1. Furthermore in this study, the 21 well candidates is reviewed as productive zones to estimate the oil flow rate. Permeability and saturation datain the productive zone which is used as a candidate in this research was determined from logging data to the log attached. While the thickness of the zone productive in this study is the interval thickness of each well perforations known by looking at the production history of candidate wells which is about to be examined and retrieve perforation data (Top perforation and bottom perforation), the watercut data and production flow rate on the candidate wells in this research.

1. Result and Discussion

Calculations of Permeability, Saturation and Resistivity Well RMT-01 is done by the sameway to each well. Result of PI calculation as shown at table 1. If the kh_p value is plotted against PI from the calculation, it can beshown by the Fig 1.

Table 1. Result of PI Calculation

Well	K (md)	h_{perfo} (ft)	$K.h_p$	r_e (ft)	WC (%)	μ (cp)	PG (psi/ft)	PI (STB/D/psi)
RMT-01	499	10	4990	393.29	97.2	0.36512	0.3651	14.29
RMT-02	752	6	13320	274.39	93.22	0.42356	0.4236	34.81
RMT-03	1849	3	5547	417.68	96.7	0.37246	0.3725	15.43
RMT-04	4370	2	8740	533.54	96.3	0.37833	0.3783	23.07
RMT-05	2102	8	16816	554.88	98	0.35337	0.3534	47.26
RMT-06	2403	8	19224	481.71	97.23	0.36468	0.3647	53.46
RMT-07	810	8	6480	295.73	95.8	0.38568	0.3857	18.37
RMT-08	3721	5	18605	554.88	98.4	0.3475	0.3475	53.17
RMT-09	1770	2	3540	609.76	98.7	0.34309	0.3431	15.82
RMT-10	3322	12	39864	442.07	98.03	0.35293	0.3529	116.02
RMT-11	1243	3	29820	329.27	99.68	0.32877	0.3288	97.5

RMT-12	1404	10	14040	204.27	93.92	0.41333	0.4133	39.49
RMT-13	6167	3	18501	375	98.7	0.34309	0.3431	56.8
RMT-14	751	14	10514	554.88	96.6	0.37393	0.3739	27.93
RMT-15	1166	6	3708	480.18	91.9	0.44295	0.4429	8.49
RMT-16	2210	6	2352	161.59	83.47	0.56674	0.5667	5.03
RMT-17	841	4	3364	0	97.84	0.35572	0.3557	0
RMT-18	2705	9	9045	210.37	90.8	0.4591	0.4591	8.49
RMT-19	7128	4	1576	326.22	88.8	0.48847	0.4885	3.47
RMT-20	810	12	1692	539.63	85.49	0.53712	0.5371	3.14
RMT-21	2060	14	2282	475.61	88.79	0.48862	0.4886	4.74

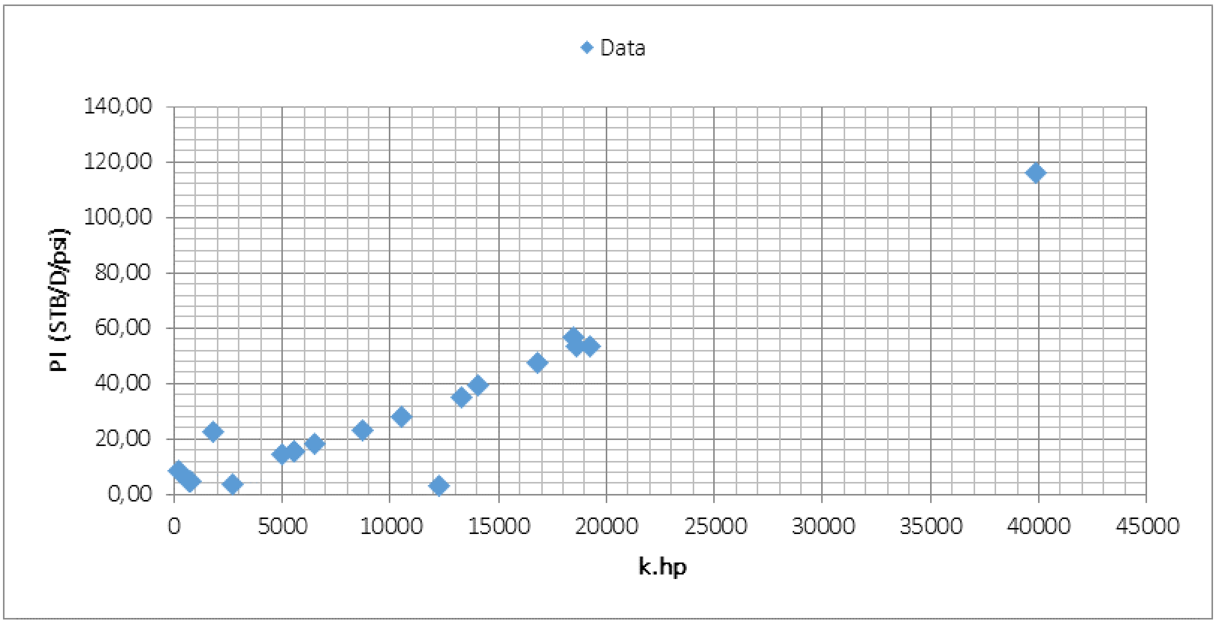

Fig 1. PI plot againts K_{hp}

Based on the **kh**$_p$ and PI data in Table 1 and after the regression done, it resulting LINEST function outputs in Excel shown in Tabel 2.

From the function LINEST output in table 2, it is generated a linear function to estimate the PI (Morrison, 2015) is as follows:

$$\mathrm{PI} = 2.94 \text{ x } 10^{-3}\mathrm{kh_p} - 1.22 \qquad (1)$$

Table 2. LINEST Function to Estimate PI

	KH	bo	
Coefficient	2.94 x10^{-3}	-1.22	
Standard Error (s_{eb})	4.37 x 10^{-6}	0.71	
Coefficient of Determination (r^2)	0.9976	1.51	*Standard Error Y* (Se_y)
F-Value	4507.63	11	*Degrees of Freedom denominator*(Df_d)
Regression Sum of Square (SS_{reg})	10215.74	24.93	*Regression Sum of Residual* (SS_{res})
t-value	67.14	1.72	

From the LINEST functions output above, do the t value and F value calculation to determine whether the function of the resulting statistics can be accepted. Calculation of PI' based on Linear Functions to Absolut Delta PI performed to determine the percentage of PI errors and differences of each well, so the results got in Table 3.

Table 3. Result of PI and PI' Calculation

Well	PI (STB/D/psi)	PI' (STB/D/psi)	Delta PI (STB/D/psi)	Abs Delta PI(STB/D/psi)	%error PI Vs PI' (%)	Abs %error (%)
RMT-01	14.29	13.21	1.08	1.08	7.54	7.54
RMT-02	34.81	37.69	-2.89	2.89	-8.29	8.29
RMT-03	15.43	14.85	0.58	0.58	3.76	3.76
RMT-04	23.07	24.23	-1.16	1.16	-5.02	5.02
RMT-05	47.26	47.97	-0.7	0.7	-1.49	1.49
RMT-06	53.46	55.04	-1.59	1.59	-2.97	2.97
RMT-07	18.37	17.59	0.78	0.78	4.25	4.25
RMT-08	53.17	53.22	-0.05	0.05	-0.09	0.09
RMT-09	15.82	14.83	0.99	0.99	6.25	6.25
RMT-10	116.02	115.7	0.33	0.33	0.28	0.28
RMT-11	97.5	86.18	11.32	11.32	11.61	11.61
RMT-12	39.49	39.81	-0.32	0.32	-0.8	0.8
RMT-13	56.8	52.92	3.88	3.88	6.84	6.84
RMT-14	27.93	29.45	-1.52	1.52	-5.45	5.45
RMT-15	8.49	9.45	-0.95	0.95	-11.23	11.23
RMT-16	5.03	5.46	-0.44	0.44	-8.67	8.67
RMT-17	6.02	8.44	-0.48	0.59	-10.12	10.12
RMT-18	8.49	9.45	-0.95	0.95	-11.23	11.23
RMT-19	3.47	3.18	0.29	0.29	8.41	8.41
RMT-20	3.14	3.52	-0.38	0.38	-12.12	12.12
RMT-21	4.74	5.26	-0.51	0.51	-10.77	10.77

The following Fig 2 is a plot between the PI againts khp based on data and a linear function to estimate the value of PI', and khp againts based on hypothetical data.

Calculation of WC Function (Watercut)

Meanwhile, water saturation (Sw) was determined from log data interpretation that is determined based on the average price of saturation. The watercut data and water saturation (Sw) are plotted on a scatter , then it will form the Fig 3 as follows.

From the field data can be conducted to determine the regression coefficients, to obtain the correlation polynomial to predict WC with LINEST function as shown in table 4.

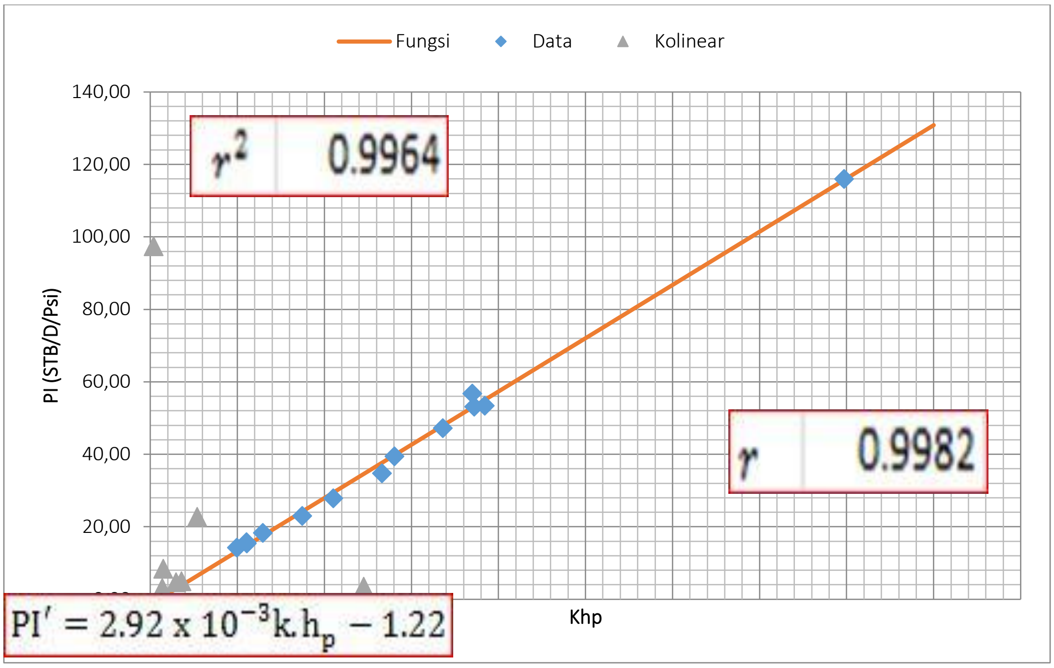

Fig 2. PI vs kh_p

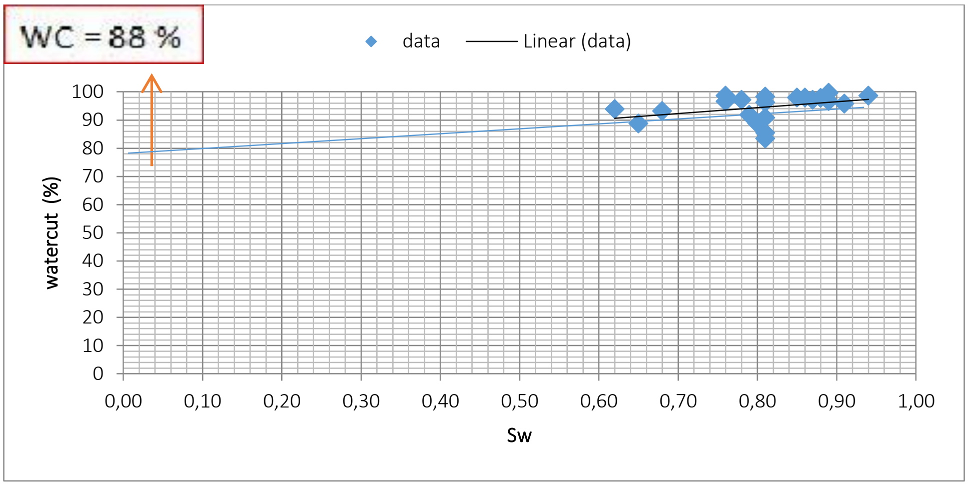

Fig 3. Plotted between Sw and WC at *Trend Linear*

Tabel 4. LINEST function to estimate WC using actual data

	Sw^3	Sw^2	Sw	Intercept	
Coefficient	332.02	-735.14	553.45	-48.28	
Standard Error (S_{eb})	122.52	215.99	106.11	10.59	
Coefficient of Determination (r^2)	0.9598	4.38	#N/A	#N/A	*Standard Error Y (Se_y)*
F-Value	151.04	19	#N/A	#N/A	*Degrees of Freedom Denominator (Df deno*
Regression Sum of Square (SS_{reg})	8692.26	364.47	#N/A	#N/A	*Regression Sum of Residual (SS_{res})*
t-value	2.71	3.4	5.22	4.56	

From the LINEST function output in Table 4 generated the polynomial function to estimate WC is:

$$WC' = 553.45Sw - 735.14Sw^2 + 332.02Sw^3 - 48.28$$

From the LINEST function output above, calculate the t value and F value to determine whether the function of the resulting acceptable statistically. Fig 4 is a plot between Sw against watercut based data, the actual equation and the equation based on the data adjusted to the data hypothetical in making the regression line.

Determination of Oil Flow Rate

Calculation was performed on each well to get the oil flow rate with a linear function of kh_p regression of the Productivity Index and polynomial functions for Swregression against watercut generated at the output function LINEST, so it can be tabulated as shown in Table 5.

Plot betweenQo and Qo 'to each well, can be seen in Fig 5. Where,

Qo : Oil Flow Rate Data (BOPD)

Qo' : Oil Flow Rate Calculation Based Functions

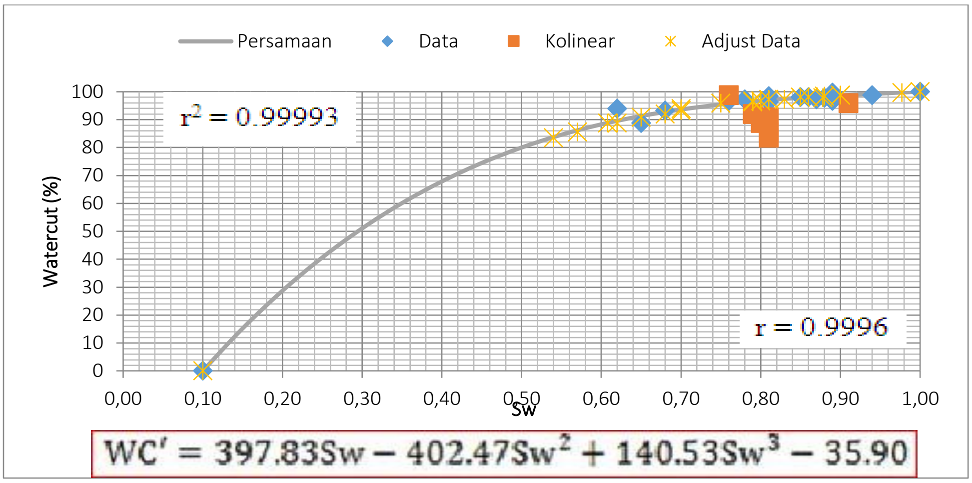

Fig 4. SwVs WC againts the equation

Table 5. Q and Q' Calculation

Well	Pres	WC	WC'	PI (STB/D/	PI' (STB/D,	PG (psi/	PG' (psi/	max (STB/D	Qmax' (STB/D)	PIP+ 100ft (psi)	PIP+ 100ft' (psi)	Q(STB/D)	Q' (STB/D)
FP-01	410	97.2	96.97	14.29	13.21	0.4316	0.4315	5859.12	5417.62	293.16	293.15	1669.71	1544.09
FP-02	550	93.22	93.58	34.81	37.69	0.429	0.4292	19143.67	20730.83	292.9	292.92	8948.81	9689.85
FP-03	580	96.7	96.74	15.43	14.85	0.4313	0.4313	8949.39	8613.3	293.13	293.13	4426.44	4260.17
FP-04	570	96.3	96.5	23.07	24.23	0.431	0.4311	13152.74	13813.12	293.1	293.11	6389.44	6709.93
FP-05	490	98	97.78	47.26	47.97	0.4321	0.432	23158.14	23503.26	293.21	293.2	9300.48	9439.77
FP-06	490	97.23	97.4	53.46	55.04	0.4316	0.4317	26193.64	26970.59	293.16	293.17	10522.25	10833.76
FP-07	590	95.8	95.37	18.37	17.59	0.4307	0.4304	10839.91	10379.43	293.07	293.04	5455.44	5224.19
FP-08	580	98.4	98.29	53.17	53.22	0.4324	0.4323	30840.57	30869.35	293.24	293.23	15248.08	15262.69
FP-09	520	98.7	98.6	15.82	14.83	0.4326	0.4325	8225.95	7711.58	293.26	293.25	3586.86	3362.67
FP-10	485	98.03	97.96	116.02	115.7	0.4321	0.4321	56271.48	56112.14	293.21	293.21	22251.67	22189.2
FP-11	560	99.68	99.67	97.5	86.18	0.4332	0.4332	54600.29	48260.6	293.32	293.32	26001.24	22982.22
FP-12	440	93.92	93.58	39.49	39.81	0.4295	0.4292	17375.99	17515.62	292.95	292.92	5807.32	5854.88
FP-13	435	98.7	98.6	56.8	52.92	0.4326	0.4325	24708.42	23019.07	293.26	293.25	8051.07	7500.95
FP-14	410	96.6	96.5	27.93	29.45	0.4312	0.4311	11449.25	12073.13	293.12	293.11	3263.85	3441.9
FP-15	550	91.9	92.71	8.49	9.45	0.4281	0.4287	4671.1	5195.52	292.81	292.87	2184.26	2428.99
FP-16	550	83.47	83.7	5.03	5.46	0.4226	0.4228	2764.24	3003.9	292.26	292.28	1295.37	1407.59
RNT-17	480	97.84	98.26	#NUM!	8.44	0.432	0.4323	#NUM!	4049.05	293.2	293.23	#NUM!	1575.51
FP-18	550	90.8	91.24	8.49	9.45	0.4274	0.4277	4671.1	5195.52	292.74	292.77	2184.88	2429.9
FP-19	550	88.8	88.79	3.47	3.18	0.4261	0.4261	1910.35	1749.7	292.61	292.61	894.01	818.83
FP-20	445	85.49	86.13	3.14	3.52	0.4239	0.4244	1397.88	1567.35	292.39	292.44	479.38	537.35
FP-21	550	88.79	89.54	4.74	5.26	0.4261	0.4266	2609.74	2890.76	292.61	292.66	1221.31	1352.57

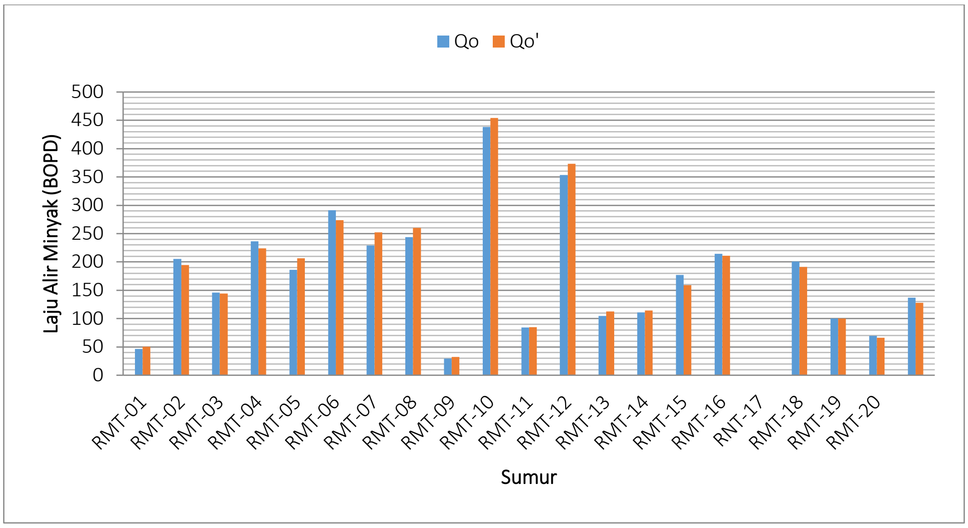

Fig 5. Plot Qo and Qo 'In each well

Based on the calculations performed to estimate the oil flow rate based on function, then from the twenty-one (21) wells studied,it is known the total of oil flow rate is 3633.68 BOPD. While from the data is known that oil flow rate total of twenty-one well studied is 3605.55 BOPD. From these results, note the difference oil flow rate based on the data of the oil flow rate based function is 28.13 BOPD. The percentage error of both oil flow rate is 0.78%.

After assessing the watercut from water saturation data and Productivity index from permeability data, the thickness of the perforation of each well, then performed the calculations of oil flow rate using both equation for estimating the flow rate of oil in new productive zones.

4. Conclussion

Based on the research are:

1. Estimated oil flow rate can be multiplied by the thickness of the perforation permeability parameters ($k.h_p$) to determine the productivity index with r^2 = 0.9964. While water saturation parameters can be used to determine watercut of polynomial functions with r2 = 0.9993
2. The regression coefficient for $k.h_p$ known by using LINEST function in Excel is 2.92x10-3, intercept is 1,49 while the Sw regression coefficient is 397.83, Sw^2 is (-5402.47), Sw^3 is 140.53 intercept is (-35). The function equation for estimating Productivity index is $\mathrm{PI} = 2.94 \times 10^{-3} \mathrm{kh_p} - 1.22$ and polynomial equations to estimate water cut is $\mathrm{WC} = 397.83\mathrm{Sw} - 402.47\mathrm{Sw}^2 + 140.53\mathrm{Sw}^3 - 35.90$
3. Oil flow rateestimation based on the function is 3633.68 BOPD while the oil flow rate data is 3605.55 BOPD, the difference is 28.13 BOPD with a percentage of 0.78% error. While the percentage of the average absolute error for each of the wells 5.47%

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