CHAPTER - 4

PERFORMANCE OF SURFACE CHOKE

CHAPTER - IV

4.1 INTRODUCTION

In this chapter performance of wellhead chokes in the production of oil and gas from Gandhar field is presented. The types of flowing wells and their control are discussed. Flow rate and Tubing head pressure data obtained during the production from Gandhar field are compared with those predicted by the existing theoretical and empirical models. The model presented in Chapter-III is compared with other well-known models in predicting the choke performance in Gandhar field.

4.2 TYPES AND CONTROL OF FLOWING WELLS

To have a better control of wells for optimized production it is necessary to identify the type a flowing well. The flowing wells are classified into three types depending upon the reservoir, namely,

1) Steady uniform rate producing wells
2) Surging wells and
3) Intermittent wells.

Most of the flowing wells fall in the first category in the early stages of their lives when the specific energy content of the fluid is high enough to lift the liquid from the reservoir to the stock tank.

In surging wells either tubing-head pressure or both the tubing-head and casing-head pressures fluctuate during production. These wells can be produced efficiently by properly selecting and placing a choke either at the wellhead or at the end of the tubing string depending upon the reservoir conditions. The choke is to be selected in such a way that at a particular flow rate the excess production of gas

is reduced to the required quantity so that the gas energy is properly used for lifting the liquid.

Intermittent wells are those in which the liquid flow from the well entirely ceases periodically. These wells can be easily controlled by placing a control valve that will open through a choke only at a particular wellhead pressure and closes when the pressure falls down.

The oil production from a well can be optimized by proper selection of the choke size. So, it is necessary to evaluate the performance of various types of chokes in a particular field.

4.3 EXPERIMENTAL

The schematic diagram of the production system employed in the present investigation is shown in Figure (4.1). The fluid from the reservoir enters the well bore through the perforations in the casing string and then flows through the tubing string upto the wellhead. From the wellhead it passes through a choke placed at the end of the flow arm of the Christmas tree. The details of the choke bean housing and photograph of typical chokes employed are shown in Figure (4.2). The upstream pressure of the choke is noted from the pressure gauge placed on top of the crown valve of the Christmas tree. The flow of fluid into the annular space between the tubing and casing is sealed by means of a packer to avoid surging of gas. The fluid then enters the central separation facility through surface flow line. The detail of the surface separation and flow measurement facility is shown in Figure (4.3). The fluid coming through the flow line is passed through three separators arranged in series and maintained at a pressure of 16, 6 and 0.5 atmospheres respectively. The pressures in the separators are maintained by means of pressure controllers. The flow rate of gas from the each separator is measured with the help of an orifice meter.

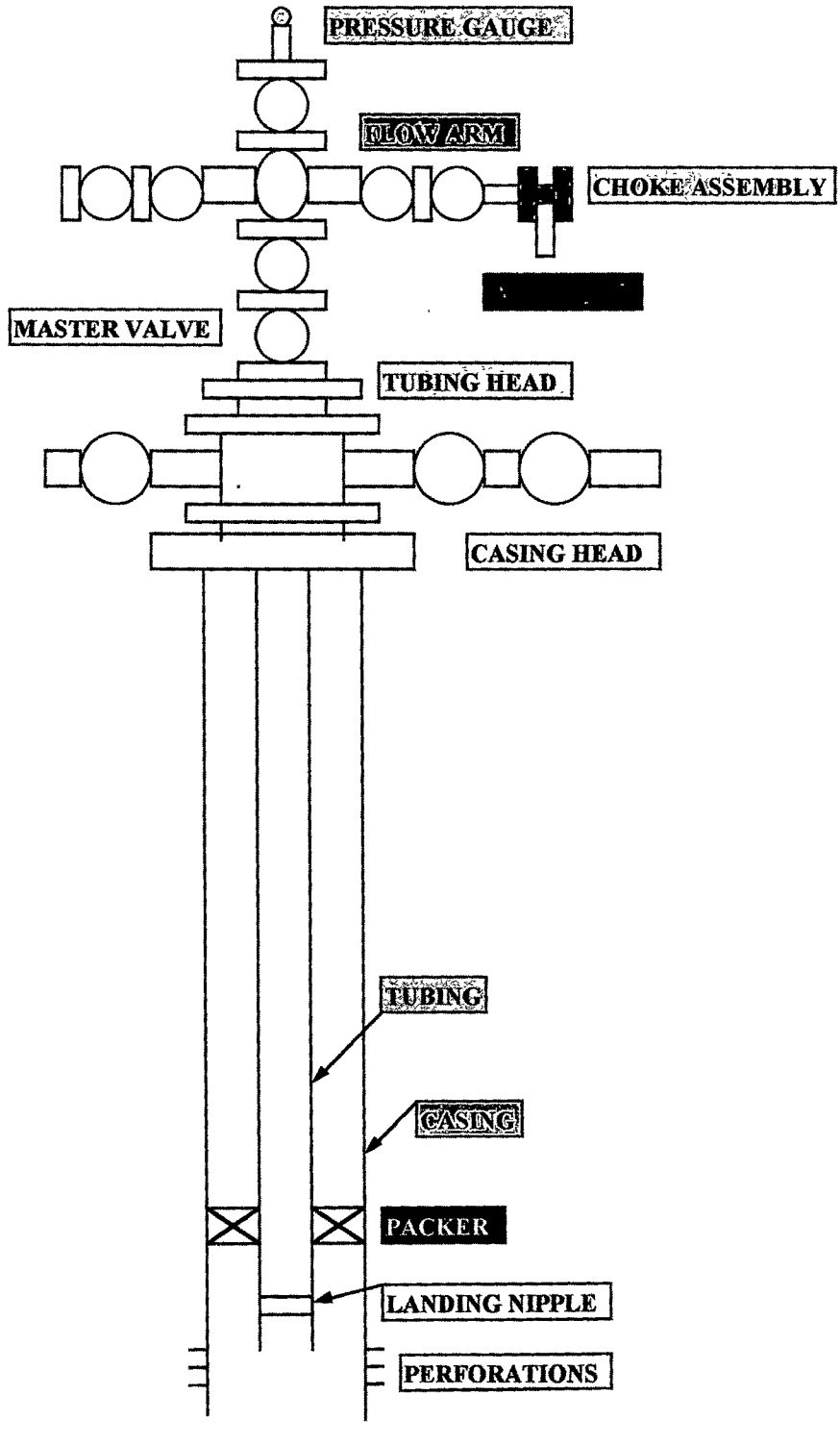
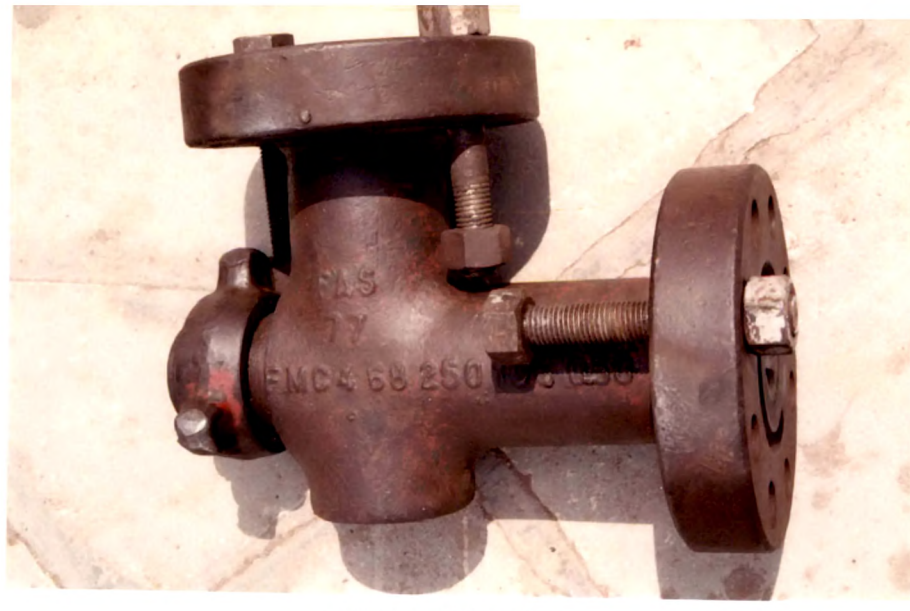


FIGURE - 4.1 SCHEMATIC DIAGRAM OF SURFACE CHOKE PRODUCTION SYSTEM



A) BEAN HOUSING

B) SURFACE CHOKES

C) BOTTOMHOLE CHOKES

FIGURE 4.2 TYPICAL BEAN HOUSING AND CHOKES USED IN FIELD TRIAL TESTS

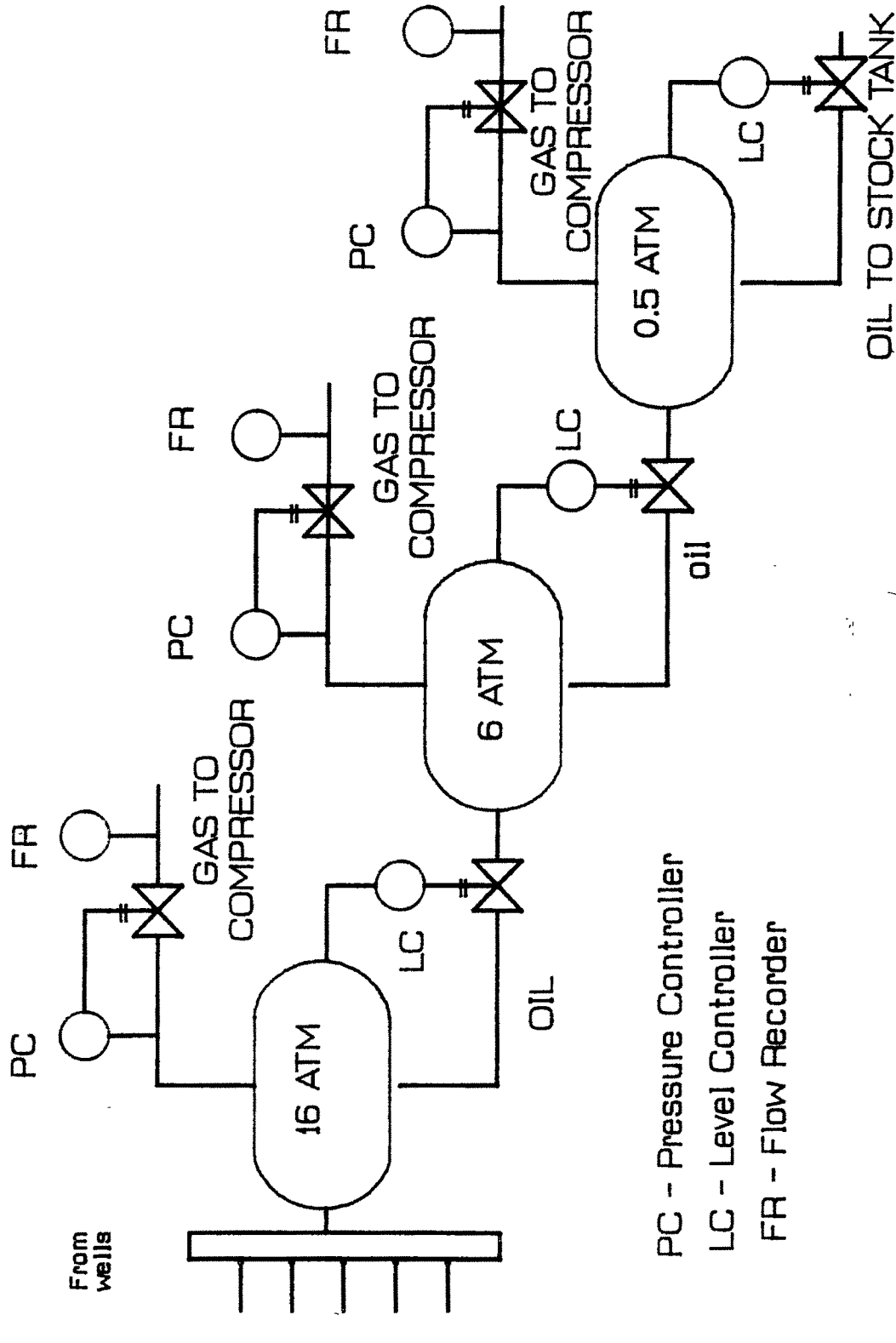


Fig. 4.3 Field trial test flow measurement system

The flowing wellhead temperature is measured by placing a temperature indicator on top of the crown valve after removing the pressure gauge. The water and oil are separated due to difference in densities. The liquid levels are controlled by float switches. The water float is lifted, as level rises, opening a dump valve at the bottom of the separator allowing the water to exit. The oil level is also controlled in the same manner with another float that operates in tandem with water float. The oil and water rates are measured by calibrated positive displacement meters. The meter records cumulative production and that are converted to flow rate by dividing by the time between two successive readings. Field trial tests have been conducted over a wide range of variables, choke size ranging from 10/64 inch to 32/64 inch , gas liquid ratio ranging from 630 to 14262 (scf / bbl) and Tubing head pressure ranging from 298 to 4295 psi.

4.3.1 TEST PROCEDURE :

The following procedure was adopted for acquiring the data on liquid flow rate, gas flow rate, Tubing head pressure and wellhead temperature.

a) **On activation, the well was allowed to flow for sufficient time through a bigger size choke (28/64" or 32/64") depending upon the expected reservoir pressure. This is done to ensure the sufficient response from the formation and for cleaning of the well.**

b) **Then the well was allowed to flow through a smaller size choke till stabilized flow rate and Tubing head pressure are attained.**

c) **At stabilized conditions the Tubing head pressure, wellhead temperature, and flow rates of oil, gas and water were measured.**

d) **At stabilized conditions liquid sample was collected and analyzed for water content in the oil stream.**

e) Flowing bottomhole temperature and pressure were measured by lowering a temperature and pressure recorder by wireline.

f) Then the well was closed for changing the choke to a next bigger size.

g) The blind end of the Christmas tree flow arm followed by the choke from the choke bean housing were removed.

h) The choke size was rechecked.

i) Then a bigger size choke was placed in the choke bean housing followed by the blind end.

j) Again the well was reopened and allowed to flow. Steps from (a) to (i) were repeated for every choke size.

k) After making flow measurements through at least three chokes, a temperature and pressure recorder was lowered and the well was closed for measurement of pressure buildup data.

4.4 RESULTS AND DISCUSSION

Water comes along with the oil in the form of free water as well as in the form of water in oil emulsion , known as associated water. The quantity of free water is measured from the separator and that of the associated from sample analysis. The total water flow rate is calculated by adding the associated water flow rate to the free water flowarte. The oil flow rate is calculated by subtracting the associated water from the total oil flow rate. The data on liquid flow rate, oil flowrate, water flow rate, tubing head pressure and gas oil ratio obtained from the field trial tests using different chokes are presented in Table 4.1 . In oil industry the oil flow rate is measured in British barrels per day, the gas flow rate is measured in standard cubic

feet, the gas oil ratio is expressed in terms of standard cubic feet per British barrel and the tubing head pressure is expressed in Pounds per square inch. Therefore, in Table 4.2, the data have been presented both in metric system as well as in terms of oilfield units. However, the correlations that are presented and tested are generally with the oilfield units.

4.4.1 PERFORMANCE OF SURFACE CHOKE

Although a number of empirical equations have been developed to predict the performance of surface chokes, they are modifications of the following equation originally proposed by Gilbert[2].

$$P_{tf} = \frac{C' q_L' \sqrt{R}}{d_c^2} \qquad \text{.....(4. 1)}$$

where P_{tf} = Tubing head pressure, psi

q_L' = liquid flow rate, Bbls/day

R = gas liquid ratio, scf/bbl

dc = choke diameter, $1/64$ inch

The value of C' in equation (4.1) has been calculated by regression analysis using field trial test data. A value of 17.125 for C' gives the minimum deviation and therefore, equation (4.1) becomes

$$P_{tf} = \frac{17.125\, q_L' \sqrt{R}}{d_c^2} \qquad \text{.....(4. 2)}$$

Values of Tubinghead pressures calculated using equation (4.2) are presented along with the measured values in Table (4.3).

4.4.2. RELIABILITY ANALYSIS

The accuracy of equation (4.2) in predicting the performance of surface choke has been tested by statistical analysis. For this purpose, the following statistical quantities have been determined using data presented in Table (4.2).

- **Average percent relative error.**
- **Average absolute percent relative error.**
- **Minimum/maximum absolute percent relative error.**
- **Standard deviation.**
- **Correlation coefficient.**

4.4.2.1 AVERAGE PERCENT RELATIVE ERROR

This is an indication of the relative deviation in percent from the experimental values and is given by

$$E_r = \frac{1}{n_d}\sum_{i=1}^{n_d} E_i \qquad \text{.....(4.3)}$$

E_i is the relative deviation in percent of an estimated value from an experimental value and is defined by

$$E_i = \left[\frac{x_{est} - x_{exp}}{x_{exp}}\right] * 100, \quad i = 1, 2, \ldots\ldots n_d \qquad \text{.....(4.4)}$$

Where x_{est} and x_{exp} represent the estimated and experimental values respectively. The lower the values of E_r, the more equally distributed are the errors between positive and negative values.

4.4.2.2 AVERAGE ABSOLUTE PERCENT RELATIVE ERROR

This is defined as:

$$E_a = \left(\frac{1}{n_d}\right)\sum_{i=1}^{n_d} |E_i| \qquad \text{.....(4.5)}$$

and indicated the relative absolute deviation in percent from the experimental values. A lower value implies a better correlation.

4.4.2.3 MINIMUM/MAXIMUM ABSOLUTE PERCENT ERROR

After the absolute percent relative error for each data point is calculated, $|E_i|, i = 1, 2, \ldots\ldots n_d$, **both the minimum and maximum values are scanned to know the range of error for each correlation :**

$$E_{min} = \min_{i=1}^{n_d} |E_i| \qquad \ldots\ldots\ldots\ldots(4.6)$$

and

$$E_{max} = \max_{i=1}^{n_d} |E_i| \qquad \ldots\ldots\ldots\ldots(4.7)$$

The accuracy of correlation can be examined by maximum absolute percent relative error. The lower the value of maximum absolute percent relative error, the higher the accuracy of the correlation is.

4.4.2.4 STANDARD DEVIATION

Standard deviation, S_x, **is a measure of dispersion and is expressed as**

$$S_x^2 = \left(\frac{1}{n_d - n - 1}\right) \sum_{i=1}^{n_d} E_i^2 \qquad \ldots\ldots\ldots\ldots(4.8)$$

Where (nd - n - 1) are the degrees of freedom in multiple regression analysis. The symbol x represents P_{tf} **or** q_L**. A lower value of standard deviation means a smaller degree of scatter.**

4.4.2.5 CORRELATION COEFFICIENT

The correlation coefficient, r , represents the degree of success in reducing the standard deviation by regression analysis. It is defined as

$$r^2 = 1 - \left(\frac{\sum_{i=1}^{n_d} \left(x_{ext} - x_{exp} \right)_i^2}{\sum_{i=1}^{n_d} \left(x_{exp} - \bar{x} \right)_i^2} \right) \qquad \text{.....(4.9)}$$

Where $\bar{x} = \frac{1}{n_d} \sum_{i=1}^{n_d} \left(x_{exp} \right)_i$ .....(4.10)

The correlation coefficient lies between 0 and 1. A value of 1 indicates a perfect correlation whereas a value of 0 infers no correlation at all among the given independent variables.

4.4.2.6 COMPUTATION

The flow rate predictions have been computed by entering the equations in MICROSOFT EXCEL and the statistical computations have also been carried out using solver and analysis tools in MICROSOFT EXCEL.

Equation (4.2) gives an average percent relative error of 0.89, average absolute percent relative error of 4.49, a minimum absolute percent relative error of 0.18, a standard deviation of 5.52and a correlation coefficient of 0.99998. This shows that the equation (4.2) is able to predict the performance of surface chokes in the wells represented in our field trial tests with a good accuracy.

4.4.3 COMPARISON OF EMPIRICAL CORRELATIONS

With the view to compare the accuracy of Equation (4.2) with other existing empirical equations in predicting the performance of surface choke at Gandhar field conditions, the test data have been fitted in Gilbert form of equation employing constants suggested by Baxendell, Achong, Ros, Mach, Pilehvari and Gilbert. The Tubing head pressure predictions by equations proposed by them are presented in Table (4.4). The average relative percent error exhibited by these empirical correlations are presented in Table (4.5).

Values of average relative percent error, minimum relative percent error, maximum relative percent error, average absolute percent error, standard deviation and correlation coefficient for these correlations have been calculated using our field trial test data and are presented in Table (4.6).

It can be seen from Table (4.6) that the equation proposed by Ros is able to predict our test data better than other equations followed by Baxendell. This may be due to the similarity in the test conditions to that of ours. However, equation (4.2), obtained in the present work, gives a lower relative percent error and standard deviation and higher correlation coefficient compared to other equations although Baxendell equation shows a lower minimum relative percent error.

Equation proposed by Pilehvari shows the maximum standard deviation of 55.22 and average relative percent error of -54.07.

CROSS PLOTS

Values of Tubing head pressures predicted by the empirical correlations have been plotted against measured values and are presented in Figures (4.4) through (4.10)

4.4.4 EVALUATION OF THE THEORETICAL MODEL

A theoretical model developed in the present work for predicting the flow through choke has been presented in Chapter - III and is given below :-

$$Q = (184648.26)\frac{C_d A_c \left[k\left(\frac{2}{k+1}\right)^{\left(\frac{k+1}{k-1}\right)} g_c P_{tf} A B (1+C) \right]^{0.5}}{A(B+C)} \qquad \text{.....(3.29)}$$

Where

$$A = \rho_o + \frac{\rho_g R_s}{5.615} + F_{wo}\rho_w \qquad \text{.....(3.25)}$$

$$B = B_o + F_{wo} \qquad \text{.....(3.26)}$$

$$C = \frac{(R_p - R_s)}{5.615} + \frac{P_{sc}}{T_{sc}} \frac{T_1 Z_1}{144 P_{tf}} \qquad \text{.....(3.30)}$$

The above equation includes a discharge coefficient C_d to accommodate the deficiencies of the model. Theoretical models developed by previous investigators have included such a discharge coefficient. It is necessary to evaluate this coefficient so that the correlation can be used for the prediction of the performance of the choke.

4.4.4.1 DETERMINATION OF DISCHARGE COEFFICIENT, (C_d)

The field trial test data presented in Table (4.2) have been used to determine the value of C_d, using regression analysis. For this purpose, a program developed in QBASIC and is presented in Appendix-I. A value of 0.758 for discharge coefficient, C_d, was found to give minimum deviation for the flow rate through surface choke. This value is in agreement with the findings of Sachdeva [14] and Perkins [15] for flowing wells. The values of C_d employed by previous works are as follows :

Model	C_d
Omana	0.263
Ashford	0.765 - 1.218
Ashford & Pierce	0.95 - 1.20
Perkins	0.826
Poettmann & Beck	1.03
Sachdeva	0.750 - 0.850

With the value of 0.758 for C_d, equation 3.29 can be written as follows :

$$Q = (0.758)(184648.26)\frac{A_c\left[k\left(\frac{2}{k+1}\right)^{\left(\frac{k+1}{k-1}\right)} g_c P_{tf} A B(1+C)\right]^{0.5}}{A(B+C)} \quad \text{.....(4.11)}$$

Where

$$A = \rho_o + \frac{\rho_g R_s}{5.615} + F_{wo}\rho_w \quad \text{.....(3.25)}$$

$$B = B_o + F_{wo} \quad \text{.....(3.26)}$$

$$C = \frac{(R_p - R_s)}{5.615} + \frac{P_{sc}}{T_{sc}}\frac{T_1 Z_1}{144 P_{tf}} \quad \text{.....(3.30)}$$

4.4.4.2 STATISTICAL ANALYSIS

In Table (4.7) values of flow rate calculated using equation (4.12) are presented along with the corresponding test data. Statistical analyses of the data have been carried out using EXCEL. Equation (4.12) predicts the flow rate with an average relative percent error of -2.14, minimum absolute relative percent error of -61.79, a maximum absolute relative percent error of 90.80, a standard deviation of 28.88 and a correlation coefficient of 0.9983.

4.4.5 EVALUATION OF OTHER MODELS

Flow rates have been calculated using the theoretical models developed by Poettmann and Beck, Omana, Ashford, Ashford and Pierce, Scahdeva and Perkins. Measured values of flow rate are presented along with the values predicted by these models in Tables (4.8) through (4.13). These tables also include the calculated values of relative percent error.

Statistical parameters like average percent relative error, average absolute percent relative error, standard deviation and correlation coefficient have also been estimated from these data and are presented in Table (4.14). Among the theoretical models, Ashford's model performs better than the other models. It gives a correlation coefficient of 0.9973 and a standard deviation of 36.01 which is comparable to the model proposed in the present investigation. As expected Omana's model gives the highest standard deviation of 203.64 as it is limited to the pressure range of 400 - 1000 psig.

The cross plots of measured flow rate against the flow rate predicted by equation (4.12) is shown in Figure 4.11. It shows that equation (4.12) predicts the flow rate with a good accuracy below a flow rate of 1500 Bbls/day whereas the data become scattered at higher flow rates. Cross plots prepared for the correlations developed by previous investigators are shown in Figures (4.12) through 4.17. Here also it can be seen that the equation proposed by Ashford predicts the data with a good accuracy.

The validity of equation (4.12) has also been tested with 47 literature data reported by Omana and 27 data by Ashford and Pierce. The predicted values are presented along with the literature values and relative percent error in Tables (4.15) and (4.16) respectively. The present model shows a standard deviation of 27.66 and average percentage error of 2.88 for the Omana's data while Omana has reported that his model predicts his own data with an average percentage error of -1.58 and standard deviation of 19.70. The present model predicts the data of Ashford and Pierce with an average percentage error of 45.848 and standard deviation of 33.47. Omana further reported that Poettman and Beck correlation predicted his data with a deviation of 36.20 percent.

Therefore, it can be concluded that the model proposed in the present investigation can be used to predict the flow rates of oil and gas in the field with a reasonably good accuracy.

4.5 CONCLUSIONS

1) **The empirical equation developed in Chapter III for Tubing head pressure prediction has been tested with the production data from Gandhar field.**

2) **The present empirical equation predicts the Gandhar field production data better than the other existing empirical models with correlation coefficient of 0.99998.**

3) **The theoretical model developed in Chapter -III has been tested with the field trial test data from Gandhar field.**

4) **A discharge coefficient of 0.758 yielded minimum deviation while predicting the flow rate through surface choke.**

5) **This model has also been tested with the reported literature data and found that this model predicts the flow rate better than other existing theoretical models.**

6) **The comparison of statistical analyses in flow rate prediction by the present model with that of other existing models shows that the present theoretical model better predicts the field trial test data from Gandhar field.**

7) **Computer programs have been developed for predicting the choke performance by the existing models including the present model.**

TABLES OF CHAPTER-IV

TABLE 4.1 FIELD TRIAL TEST DATA

SL.NO	CHOKE SIZE IN mm	OIL FLOW RATE IN M^3/DAY	WATER FLOW RATE IN M^3/DAY	LIQUID FLOW RATE IN M^3/DAY	GAS LIQUID RATIO (M^3/M^3)	TUBING HEAD PRESSURE Kg/Cm^2
1	6	89.90	0.00	89.90	268.00	116.00
2	6	80.20	0.00	80.20	303.00	116.00
3	6	91.40	0.00	91.40	278.00	116.00
4	6	90.20	0.00	90.20	260.00	116.00
5	6	83.30	0.00	83.30	294.00	116.00
6	6	70.10	0.00	70.10	243.00	95.00
7	6	74.27	10.13	84.40	266.00	116.00
8	6	76.80	0.00	76.80	338.00	123.00
9	6	75.10	0.00	75.10	484.00	123.00
10	7	102.00	0.00	102.00	363.00	123.00
11	6	75.10	0.00	75.10	484.00	123.00
12	5	47.90	0.00	47.90	532.00	123.00
13	5	52.40	0.00	52.40	479.00	123.00
14	5	60.00	0.00	60.00	346.00	123.00
15	5	39.60	0.00	39.60	523.00	116.00
16	5	63.00	0.00	63.00	221.00	116.00
17	10	32.00	0.00	32.00	591.00	21.00
18	10	34.00	0.00	34.00	567.00	21.00
19	6	62.10	0.00	62.10	992.00	148.00
20	5	40.60	0.00	40.60	1680.00	181.00
21	5	38.30	0.00	38.30	1385.00	181.00
22	5	42.10	0.00	42.10	1318.00	177.00
23	5	42.70	0.00	42.70	1197.00	177.00
24	5	53.10	0.00	53.10	1010.00	183.00
25	5	36.00	0.00	36.00	1764.00	183.00
26	5	38.40	0.00	38.40	2098.00	183.00
27	5	27.10	0.00	27.10	2415.00	165.00
28	6	96.90	0.00	96.90	112.00	84.00
29	4	41.00	0.00	41.00	130.00	84.00
30	12	254.03	11.97	266.00	379.00	95.00
31	6	53.10	0.00	53.10	958.00	129.00
32	4	35.10	0.00	35.10	857.00	176.00
33	5	33.90	0.00	33.90	1688.00	176.00
34	6	71.70	0.00	71.70	207.00	80.00
35	6	71.70	0.00	71.70	207.00	84.00

TABLE 4.1 FIELD TRIAL TEST DATA

SL.NO	CHOKE SIZE IN mm	OIL FLOW RATE IN M^3/DAY	WATER FLOW RATE IN M^3/DAY	LIQUID FLOW RATE IN M^3/DAY	GAS LIQUID RATIO (M^3/M^3)	TUBING HEAD PRESSURE Kg/Cm^2
36	6	85.20	0.00	85.20	498.00	143.00
37	6	87.40	0.00	87.40	459.00	147.00
38	4	36.90	0.00	36.90	471.00	150.00
39	6	87.00	0.00	87.00	457.00	150.00
40	4	34.70	0.00	34.70	507.00	150.00
41	6	87.50	0.00	87.50	439.00	138.00
42	6	81.10	0.00	81.10	453.00	138.00
43	4	25.20	0.00	25.20	1156.00	169.00
44	6	61.10	0.00	61.10	1127.00	170.00
45	6	62.00	0.00	62.00	1188.00	170.00
46	6	66.90	0.00	66.90	1105.00	170.00
47	6	36.00	0.00	36.00	2504.00	150.00
48	6	74.20	0.00	74.20	794.00	168.00
49	9	166.43	6.57	173.00	379.00	105.00
50	6	59.20	0.00	59.20	1379.00	178.00
51	6	62.30	0.00	62.30	1386.00	181.00
52	6	71.60	0.00	71.60	245.00	88.00
53	7	124.00	0.00	124.00	165.00	95.00
54	10	118.00	0.00	118.00	418.00	67.00
55	7	144.40	7.60	152.00	178.00	113.00
56	7	144.40	7.60	152.00	178.00	113.00
57	7	144.40	7.60	152.00	178.00	113.00
58	7	137.00	0.00	137.00	203.00	113.00
59	6	88.30	0.00	88.30	271.00	113.00
60	6	88.30	0.00	88.30	271.00	113.00
61	6	96.10	0.00	96.10	230.00	110.00
62	8	139.00	0.00	139.00	354.00	116.00
63	7	112.00	0.00	112.00	384.00	116.00
64	6	112.00	0.00	112.00	121.00	95.00
65	8	188.00	0.00	188.00	148.00	95.00
66	8	155.03	3.98	159.00	212.00	95.00
67	6	59.60	0.00	59.60	216.00	70.00
68	4	22.00	0.00	22.00	2516.00	185.00
69	8	139.68	4.32	144.00	249.00	110.00
70	6	97.80	0.00	97.80	284.00	127.00

TABLE 4.1 FIELD TRIAL TEST DATA

SL.NO	CHOKE SIZE IN mm	OIL FLOW RATE IN M^3/DAY	WATER FLOW RATE IN M^3/DAY	LIQUID FLOW RATE IN M^3/DAY	GAS LIQUID RATIO (M^3/M^3)	TUBING HEAD PRESSURE Kg/Cm^2
71	6	86.20	0.00	86.20	256.00	105.00
72	6	68.00	0.00	68.00	320.00	98.00
73	4	23.30	0.00	23.30	720.00	105.00
74	4	24.00	0.00	24.00	1348.00	148.00
75	6	31.90	0.00	31.90	795.00	69.00
76	6	29.10	0.00	29.10	922.00	69.00
77	6	28.00	0.00	28.00	1104.00	70.00
78	6	35.70	0.00	35.70	684.00	70.00
79	6	101.00	0.00	101.00	328.00	137.00
80	8	158.00	0.00	158.00	346.00	132.00
81	8	157.00	0.00	157.00	377.00	132.00
82	9	168.00	0.00	168.00	450.00	132.00
83	10	221.00	0.00	221.00	536.00	134.00
84	9	154.00	21.00	175.00	476.00	125.00
85	8	111.00	0.00	111.00	2378.00	207.00
86	6	51.00	0.00	51.00	2540.00	207.00
87	6	59.60	0.00	59.60	2202.00	207.00
88	5	43.60	0.00	43.60	2179.00	211.00
89	6	42.25	22.75	65.00	1856.00	211.00
90	7	265.20	7.80	273.00	340.00	295.00
91	6	138.60	59.40	198.00	363.00	302.00
92	6	148.50	49.50	198.00	363.00	302.00
93	6	158.40	39.60	198.00	363.00	302.00
94	8	332.92	73.08	406.00	220.00	274.00
95	9	165.94	265.07	431.00	337.00	267.00
96	8	144.10	152.90	297.00	473.00	281.00
97	8	144.10	152.90	297.00	473.00	281.00
98	8	144.10	152.90	297.00	473.00	281.00
99	8	144.10	152.90	297.00	473.00	281.00
100	4	21.60	2.40	24.00	1522.00	159.00
101	8	113.50	12.50	126.00	458.00	116.00
102	8	100.00	9.00	109.00	512.00	120.00

TABLE 4.2 FIELD TRIAL TEST DATA
(Both in FPS and MKS units)

SL.NO.	CHOKE SIZE IN mm	CHOKE SIZE IN 1/64 inch	FLOW RATE IN M^3/DAY	FLOW RATE IN Bbls/DAY	GAS OIL RATIO (M^3/M^3)	GAS OIL RATIO (Scf/Bbl)	TUBING HEAD PRESSURE Kg/Cm^2	TUBING HEAD PRESSURE Psi
1	6.00	15.12	89.90	565.47	268.00	1504.82	116.00	1649.52
2	6.00	15.12	80.20	504.46	303.00	1701.35	116.00	1649.52
3	6.00	15.12	91.40	574.91	278.00	1560.97	116.00	1649.52
4	6.00	15.12	90.20	567.36	260.00	1459.90	116.00	1649.52
5	6.00	15.12	83.30	523.96	294.00	1650.81	116.00	1649.52
6	6.00	15.12	70.10	440.93	243.00	1364.45	95.00	1350.90
7	6.00	15.12	84.40	530.88	266.00	1493.59	116.00	1649.52
8	6.00	15.12	76.80	483.07	338.00	1897.87	123.00	1749.06
9	6.00	15.12	75.10	472.38	484.00	2717.66	123.00	1749.06
10	7.00	17.64	102.00	641.58	363.00	2038.25	123.00	1749.06
11	6.00	15.12	75.10	472.38	484.00	2717.66	123.00	1749.06
12	5.00	12.60	47.90	301.29	532.00	2987.18	123.00	1749.06
13	5.00	12.60	52.40	329.60	479.00	2689.59	123.00	1749.06
14	5.00	12.60	60.00	377.40	346.00	1942.79	123.00	1749.06
15	5.00	12.60	39.60	249.08	523.00	2936.65	116.00	1649.52
16	5.00	12.60	63.00	396.27	221.00	1240.92	116.00	1649.52
17	10.00	25.20	32.00	201.28	591.00	3318.47	21.00	298.62
18	10.00	25.20	34.00	213.86	567.00	3183.71	21.00	298.62
19	6.00	15.12	62.10	390.61	992.00	5570.08	148.00	2104.56
20	5.00	12.60	40.60	255.37	1680.00	9433.20	181.00	2573.82
21	5.00	12.60	38.30	240.91	1385.00	7776.78	181.00	2573.82
22	5.00	12.60	42.10	264.81	1318.00	7400.57	177.00	2516.94
23	5.00	12.60	42.70	268.58	1197.00	6721.16	177.00	2516.94
24	5.00	12.60	53.10	334.00	1010.00	5671.15	183.00	2602.26
25	5.00	12.60	36.00	226.44	1764.00	9904.86	183.00	2602.26
26	5.00	12.60	38.40	241.54	2098.00	11780.27	183.00	2602.26
27	5.00	12.60	27.10	170.46	2415.00	13560.23	165.00	2346.30
28	6.00	15.12	96.90	609.50	112.00	628.88	84.00	1194.48
29	4.00	10.08	41.00	257.89	130.00	729.95	84.00	1194.48
30	12.00	30.24	266.00	1673.14	379.00	2128.09	95.00	1350.90
31	6.00	15.12	53.10	334.00	958.00	5379.17	129.00	1834.38
32	4.00	10.08	35.10	220.78	857.00	4812.06	176.00	2502.72
33	5.00	12.60	33.90	213.23	1688.00	9478.12	176.00	2502.72
34	6.00	15.12	71.70	450.99	207.00	1162.31	80.00	1137.60
35	6.00	15.12	71.70	450.99	207.00	1162.31	84.00	1194.48

TABLE 4.2 FIELD TRIAL TEST DATA
(Both in FPS and MKS units)

SL.NO.	CHOKE SIZE IN mm	CHOKE SIZE IN 1/64 inch	FLOW RATE IN M^3/DAY	FLOW RATE IN Bbls/DAY	GAS OIL RATIO (M^3/M^3)	GAS OIL RATIO (Scf/Bbl)	TUBING HEAD PRESSURE Kg/Cm^2	TUBING HEAD PRESSURE Psi
36	6.00	15.12	85.20	535.91	498.00	2796.27	143.00	2033.46
37	6.00	15.12	87.40	549.75	459.00	2577.29	147.00	2090.34
38	4.00	10.08	36.90	232.10	471.00	2644.67	150.00	2133.00
39	6.00	15.12	87.00	547.23	457.00	2566.06	150.00	2133.00
40	4.00	10.08	34.70	218.26	507.00	2846.81	150.00	2133.00
41	6.00	15.12	87.50	550.38	439.00	2464.99	138.00	1962.36
42	6.00	15.12	81.10	510.12	453.00	2543.60	138.00	1962.36
43	4.00	10.08	25.20	158.51	1156.00	6490.94	169.00	2403.18
44	6.00	15.12	61.10	384.32	1127.00	6328.11	170.00	2417.40
45	6.00	15.12	62.00	389.98	1188.00	6670.62	170.00	2417.40
46	6.00	15.12	66.90	420.80	1105.00	6204.58	170.00	2417.40
47	6.00	15.12	36.00	226.44	2504.00	14059.96	150.00	2133.00
48	6.00	15.12	74.20	466.72	794.00	4458.31	168.00	2388.96
49	9.00	22.68	173.00	1088.17	379.00	2128.09	105.00	1493.10
50	6.00	15.12	59.20	372.37	1379.00	7743.09	178.00	2531.16
51	6.00	15.12	62.30	391.87	1386.00	7782.39	181.00	2573.82
52	6.00	15.12	71.60	450.36	245.00	1375.68	88.00	1251.36
53	7.00	17.64	124.00	779.96	165.00	926.48	95.00	1350.90
54	10.00	25.20	118.00	742.22	418.00	2347.07	67.00	952.74
55	7.00	17.64	152.00	956.08	178.00	999.47	113.00	1606.86
56	7.00	17.64	152.00	956.08	178.00	999.47	113.00	1606.86
57	7.00	17.64	152.00	956.08	178.00	999.47	113.00	1606.86
58	7.00	17.64	137.00	861.73	203.00	1139.85	113.00	1606.86
59	6.00	15.12	88.30	555.41	271.00	1521.67	113.00	1606.86
60	6.00	15.12	88.30	555.41	271.00	1521.67	113.00	1606.86
61	6.00	15.12	96.10	604.47	230.00	1291.45	110.00	1564.20
62	8.00	20.16	139.00	874.31	354.00	1987.71	116.00	1649.52
63	7.00	17.64	112.00	704.48	384.00	2156.16	116.00	1649.52
64	6.00	15.12	112.00	704.48	121.00	679.42	95.00	1350.90
65	8.00	20.16	188.00	1182.52	148.00	831.02	95.00	1350.90
66	8.00	20.16	159.00	1000.11	212.00	1190.38	95.00	1350.90
67	6.00	15.12	59.60	374.88	216.00	1212.84	70.00	995.40
68	4.00	10.08	22.00	138.38	2516.00	14127.34	185.00	2630.70
69	8.00	20.16	144.00	905.76	249.00	1398.14	110.00	1564.20
70	6.00	15.12	97.80	615.16	284.00	1594.66	127.00	1805.94

TABLE 4.2 FIELD TRIAL TEST DATA
(Both in FPS and MKS units)

SL.NO.	CHOKE SIZE IN mm	CHOKE SIZE IN 1/64 inch	FLOW RATE IN M^3/DAY	FLOW RATE IN Bbls/DAY	GAS OIL RATIO (M^3/M^3)	GAS OIL RATIO (Scf/Bbl)	TUBING HEAD PRESSURE Kg/Cm^2	TUBING HEAD PRESSURE Psi
71	6.00	15.12	86.20	542.20	256.00	1437.44	105.00	1493.10
72	6.00	15.12	68.00	427.72	320.00	1796.80	98.00	1393.56
73	4.00	10.08	23.30	146.56	720.00	4042.80	105.00	1493.10
74	4.00	10.08	24.00	150.96	1348.00	7569.02	148.00	2104.56
75	6.00	15.12	31.90	200.65	795.00	4463.93	69.00	981.18
76	6.00	15.12	29.10	183.04	922.00	5177.03	69.00	981.18
77	6.00	15.12	28.00	176.12	1104.00	6198.96	70.00	995.40
78	6.00	15.12	35.70	224.55	684.00	3840.66	70.00	995.40
79	6.00	15.12	101.00	635.29	328.00	1841.72	137.00	1948.14
80	8.00	20.16	158.00	993.82	346.00	1942.79	132.00	1877.04
81	8.00	20.16	157.00	987.53	377.00	2116.86	132.00	1877.04
82	9.00	22.68	168.00	1056.72	450.00	2526.75	132.00	1877.04
83	10.00	25.20	221.00	1390.09	536.00	3009.64	134.00	1905.48
84	9.00	22.68	175.00	1100.75	476.00	2672.74	125.00	1777.50
85	8.00	20.16	111.00	698.19	2378.00	13352.47	207.00	2943.54
86	6.00	15.12	51.00	320.79	2540.00	14262.10	207.00	2943.54
87	6.00	15.12	59.60	374.88	2202.00	12364.23	207.00	2943.54
88	5.00	12.60	43.60	274.24	2179.00	12235.09	211.00	3000.42
89	6.00	15.12	65.00	408.85	1856.00	10421.44	211.00	3000.42
90	7.00	17.64	273.00	1717.17	340.00	1909.10	295.00	4194.90
91	6.00	15.12	198.00	1245.42	363.00	2038.25	302.00	4294.44
92	6.00	15.12	198.00	1245.42	363.00	2038.25	302.00	4294.44
93	6.00	15.12	198.00	1245.42	363.00	2038.25	302.00	4294.44
94	8.00	20.16	406.00	2553.74	220.00	1235.30	274.00	3896.28
95	9.00	22.68	431.00	2710.99	337.00	1892.26	267.00	3796.74
96	8.00	20.16	297.00	1868.13	473.00	2655.90	281.00	3995.82
97	8.00	20.16	297.00	1868.13	473.00	2655.90	281.00	3995.82
98	8.00	20.16	297.00	1868.13	473.00	2655.90	281.00	3995.82
99	8.00	20.16	297.00	1868.13	473.00	2655.90	281.00	3995.82
100	4.00	10.08	24.00	150.96	1522.00	8546.03	159.00	2260.98
101	8.00	20.16	126.00	792.54	458.00	2571.67	116.00	1649.52
102	8.00	20.16	109.00	685.61	512.00	2874.88	120.00	1706.40

Table 4.3 Tubinghead Pressure Prediction by the Present Empirical Correlation for the Field trial test data

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	TUBING HEAD PRESSURE psi PREDICTED	PERCENTAGE ERROR
1	1649.52	1643.57	0.22
2	1649.52	1559.04	-4.93
3	1649.52	1701.88	3.78
4	1649.52	1624.26	-0.96
5	1649.52	1595.07	-2.74
6	1350.90	1220.34	-9.14
7	1649.52	1537.25	-6.26
8	1749.06	1576.81	-9.32
9	1749.06	1845.12	6.11
10	1749.06	1594.49	-8.31
11	1749.06	1845.12	6.11
12	1749.06	1776.70	2.17
13	1749.06	1844.26	6.06
14	1749.06	1794.79	3.21
15	1649.52	1456.36	-11.19
16	1649.52	1506.12	-8.16
17	298.62	312.76	5.35
18	298.62	325.49	9.63
19	2104.56	2184.28	4.39
20	2573.82	2676.11	4.58
21	2573.82	2292.17	-10.42
22	2516.94	2457.90	-1.78
23	2516.94	2375.74	-5.06
24	2602.26	2713.81	4.90
25	2602.26	2431.51	-6.02
26	2602.26	2828.51	9.33
27	2346.30	2141.66	-8.19
28	1194.48	1145.23	-3.56
29	1194.48	1174.62	-1.09
30	1350.90	1445.78	7.65
31	1834.38	1835.43	0.64
32	2502.72	2581.91	3.77
33	2502.72	2239.80	-9.98
34	1137.60	1152.03	1.86
35	1194.48	1152.03	-2.99

Table 4.3 Tubinghead Pressure Prediction by the Present Empirical Correlation for the Field trial test data

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	TUBING HEAD PRESSURE psi PREDICTED	PERCENTAGE ERROR
36	2033.46	2123.32	5.03
37	2090.34	2091.12	0.62
38	2133.00	2012.24	-5.11
39	2133.00	2077.01	-2.06
40	2133.00	1963.26	-7.42
41	1962.36	2047.39	4.94
42	1962.36	1927.66	-1.19
43	2403.18	2152.90	-9.89
44	2417.40	2290.68	-4.69
45	2417.40	2386.50	-0.70
46	2417.40	2483.52	3.34
47	2133.00	2011.78	-5.13
48	2388.96	2334.94	-1.69
49	1493.10	1671.65	12.61
50	2531.16	2455.08	-2.44
51	2573.82	2590.18	1.22
52	1251.36	1251.58	0.60
53	1350.90	1306.87	-2.69
54	952.74	969.92	2.40
55	1606.86	1663.88	4.15
56	1606.86	1663.88	4.15
57	1606.86	1663.88	4.15
58	1606.86	1601.53	0.25
59	1606.86	1623.33	1.61
60	1606.86	1623.33	1.61
61	1564.20	1627.60	4.66
62	1649.52	1642.86	0.18
63	1649.52	1800.74	9.81
64	1350.90	1375.85	2.44
65	1350.90	1436.72	6.97
66	1350.90	1454.28	8.28
67	995.40	978.21	-1.15
68	2630.70	2772.82	6.02
69	1564.20	1427.40	-8.21
70	1805.94	1840.60	2.51

Table 4.3 Tubinghead Pressure Prediction by the Present Empirical Correlation for the Field trial test data

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	TUBING HEAD PRESSURE psi PREDICTED	PERCENTAGE ERROR
71	1493.10	1540.24	3.76
72	1393.56	1358.45	-1.95
73	1493.10	1570.96	5.83
74	2104.56	2214.11	5.82
75	981.18	1004.47	2.97
76	981.18	986.78	1.16
77	995.40	1038.97	4.99
78	995.40	1042.70	5.36
79	1948.14	2042.77	5.47
80	1877.04	1846.20	-1.07
81	1877.04	1914.93	2.61
82	1877.04	1768.86	-5.21
83	1905.48	2057.02	8.58
84	1777.50	1895.05	7.24
85	2943.54	3400.26	16.19
86	2943.54	2870.44	-1.91
87	2943.54	3123.32	6.73
88	3000.42	3272.94	9.72
89	3000.42	3127.26	4.84
90	4194.90	4130.19	-0.97
91	4294.44	4212.88	-1.33
92	4294.44	4212.88	-1.33
93	4294.44	4212.88	-1.33
94	3896.28	3782.87	-2.34
95	3796.74	3927.09	4.04
96	3995.82	4057.61	2.14
97	3995.82	4057.61	2.14
98	3995.82	4057.61	2.14
99	3995.82	4057.61	2.14
100	2260.98	2352.68	4.66
101	1649.52	1693.90	3.29
102	1706.40	1549.33	-8.67

Table 4.4 Tubinghead Pressure predictions by various existing empirical correlations for the field trial test data.

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
1	1649.52	1811.62	1669.96	1553.62	1521.89	1517.36	845.79
2	1649.52	1728.17	1584.07	1482.06	1470.44	1439.32	784.08
3	1649.52	1879.06	1729.21	1611.45	1584.57	1571.20	869.82
4	1649.52	1787.83	1650.34	1533.22	1497.18	1499.53	840.60
5	1649.52	1765.66	1620.68	1514.21	1497.64	1472.59	806.74
6	1350.90	1339.07	1239.94	1148.37	1113.52	1126.64	639.60
7	1649.52	1693.84	1561.94	1452.62	1421.84	1419.21	792.18
8	1749.06	1756.69	1602.14	1506.51	1511.80	1455.73	776.98
9	1749.06	2089.83	1874.75	1792.21	1866.92	1703.43	850.14
10	1749.06	1812.70	1620.09	1544.99	1574.04	1472.05	762.23
11	1749.06	2089.83	1874.75	1792.21	1866.92	1703.43	850.14
12	1749.06	1980.98	1805.23	1711.30	1783.92	1640.27	820.57
13	1749.06	2046.41	1873.88	1767.82	1822.83	1702.64	868.65
14	1749.06	1961.94	1823.61	1694.84	1689.46	1656.97	898.36
15	1649.52	1622.54	1479.75	1401.65	1458.54	1344.53	674.77
16	1649.52	1612.79	1530.31	1393.23	1325.54	1390.47	819.79
17	298.62	378.17	317.78	317.75	346.69	288.74	131.24
18	298.62	392.81	330.71	330.06	358.57	300.49	137.64
19	2104.56	2557.01	2219.36	2192.86	2461.28	2016.55	880.02
20	2573.82	3145.88	2719.09	2717.62	3192.82	2470.62	996.82
21	2573.82	2670.72	2328.98	2307.14	2656.67	2116.16	885.20
22	2516.94	2857.29	2497.37	2468.31	2827.64	2269.16	958.04
23	2516.94	2749.57	2413.89	2375.26	2693.93	2193.31	942.84
24	2602.26	3116.39	2757.39	2692.14	2999.85	2505.42	1111.77
25	2602.26	2864.76	2470.55	2474.76	2922.29	2244.79	897.48
26	2602.26	3359.19	2873.93	2901.88	3489.00	2611.31	1010.70
27	2346.30	2560.00	2176.06	2211.49	2698.13	1977.21	745.40
28	1194.48	1212.67	1163.62	1039.97	930.36	1057.29	693.78
29	1194.48	1197.72	1193.49	1043.94	929.47	1084.43	723.60
30	1350.90	1747.50	1469.00	1457.65	1532.49	1334.76	646.13
31	1834.38	2145.19	1864.91	1839.68	2057.40	1694.49	744.32
32	2502.72	2871.26	2623.37	2502.62	2711.02	2383.65	1117.84
33	2502.72	2633.56	2275.77	2275.04	2674.17	2067.81	833.56
34	1137.60	1254.83	1170.53	1076.12	1026.21	1063.57	622.18
35	1194.48	1254.83	1170.53	1076.12	1026.21	1063.57	622.18

Table 4.4 Tubinghead Pressure predictions by various existing empirical correlations for the field trial test data.

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
36	2033.46	2408.09	2157.42	2065.14	2157.62	1960.27	973.12
37	2090.34	2362.69	2124.70	2026.21	2099.06	1930.55	973.09
38	2133.00	2176.98	2044.56	1897.47	1931.42	1857.73	974.38
39	2133.00	2346.27	2110.36	2012.13	2083.54	1917.52	967.32
40	2133.00	2131.19	1994.78	1857.56	1905.34	1812.50	937.66
41	1962.36	2308.55	2080.27	1979.78	2041.48	1890.18	960.72
42	1962.36	2176.69	1958.62	1866.70	1931.17	1779.64	899.24
43	2403.18	2427.36	2187.47	2115.70	2364.34	1987.58	881.36
44	2417.40	2697.35	2327.46	2313.21	2631.04	2114.78	901.13
45	2417.40	2817.00	2424.82	2415.82	2762.86	2203.24	929.62
46	2417.40	2921.78	2523.41	2505.68	2844.12	2292.82	980.60
47	2133.00	2457.55	2044.09	2107.56	2604.66	1857.30	681.66
48	2388.96	2705.52	2372.43	2320.22	2544.62	2155.64	980.72
49	1493.10	1957.56	1698.49	1651.77	1711.77	1543.28	771.09
50	2531.16	2917.89	2494.50	2502.34	2906.53	2266.55	930.04
51	2573.82	3079.19	2631.78	2640.67	3068.81	2391.29	980.29
52	1251.36	1373.86	1271.67	1178.21	1143.42	1155.47	654.96
53	1350.90	1432.79	1327.85	1221.19	1146.21	1206.51	723.99
54	952.74	1154.24	985.49	969.84	1020.72	895.44	434.21
55	1606.86	1830.58	1690.60	1560.23	1476.02	1536.11	908.79
56	1606.86	1830.58	1690.60	1560.23	1476.02	1536.11	908.79
57	1606.86	1830.58	1690.60	1560.23	1476.02	1536.11	908.79
58	1606.86	1772.68	1627.25	1510.88	1449.00	1478.55	853.50
59	1606.86	1790.22	1649.40	1535.27	1505.66	1498.68	833.63
60	1606.86	1790.22	1649.40	1535.27	1505.66	1498.68	833.63
61	1564.20	1781.44	1653.74	1527.74	1472.93	1502.62	861.87
62	1649.52	1893.14	1669.24	1604.95	1641.79	1516.71	777.55
63	1649.52	2052.48	1829.66	1749.36	1792.71	1662.46	851.83
64	1350.90	1462.06	1397.95	1253.84	1130.74	1270.20	821.53
65	1350.90	1590.49	1459.79	1348.38	1259.73	1326.40	800.43
66	1350.90	1636.77	1477.64	1387.61	1345.76	1342.61	757.56
67	995.40	1067.59	993.92	915.55	876.95	903.10	524.11
68	2630.70	3240.18	2817.35	2824.17	3421.94	2559.90	981.51
69	1564.20	1618.45	1450.32	1372.08	1353.14	1317.79	721.52
70	1805.94	2034.21	1870.16	1744.51	1719.22	1699.26	936.96

Table 4.4 Tubinghead Pressure predictions by various existing empirical correlations for the field trial test data.

SL.NO.	TUBING HEAD PRESSURE psi MEASURED	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
71	1493.10	1694.15	1564.97	1452.88	1416.44	1421.97	799.43
72	1393.56	1509.61	1380.27	1294.63	1291.79	1254.14	676.26
73	1493.10	1733.07	1596.19	1510.56	1606.98	1450.33	702.67
74	2104.56	2514.08	2249.67	2191.30	2488.27	2044.10	880.75
75	981.18	1163.96	1020.60	998.19	1094.88	927.33	421.79
76	981.18	1151.28	1002.62	987.32	1099.78	911.01	403.04
77	995.40	1222.26	1055.66	1048.20	1189.66	959.19	410.30
78	995.40	1199.93	1059.44	1029.04	1111.20	962.63	450.34
79	1948.14	2272.66	2075.57	1949.00	1949.73	1885.91	1012.24
80	1877.04	2125.22	1875.85	1801.71	1838.69	1704.43	877.53
81	1877.04	2213.06	1945.69	1876.18	1931.85	1767.89	895.71
82	1877.04	2087.83	1797.27	1761.69	1858.58	1633.03	790.15
83	1905.48	2476.10	2090.05	2080.52	2247.03	1899.06	879.05
84	1777.50	2242.56	1925.48	1892.25	2008.02	1749.53	837.67
85	2943.54	4277.06	3454.87	3625.99	4521.81	3139.16	1127.07
86	2943.54	3508.77	2916.53	3009.07	3724.33	2650.02	970.01
87	2943.54	3792.89	3173.47	3252.73	3966.56	2883.48	1084.03
88	3000.42	3893.79	3325.50	3363.71	4060.23	3021.62	1161.26
89	3000.42	3767.93	3177.47	3231.32	3871.02	2887.12	1120.66
90	4194.90	4681.30	4196.51	3989.94	4037.38	3813.04	1998.72
91	4294.44	4708.90	4280.54	4038.29	4082.63	3889.38	2048.38
92	4294.44	4708.90	4280.54	4038.29	4082.63	3889.38	2048.38
93	4294.44	4708.90	4280.54	4038.29	4082.63	3889.38	2048.38
94	3896.28	4264.81	3843.61	3615.60	3520.08	3492.39	1956.95
95	3796.74	4574.00	3990.15	3859.49	3951.13	3625.53	1851.69
96	3995.82	4738.51	4122.77	4017.19	4235.14	3746.04	1819.12
97	3995.82	4738.51	4122.77	4017.19	4235.14	3746.04	1819.12
98	3995.82	4738.51	4122.77	4017.19	4235.14	3746.04	1819.12
99	3995.82	4738.51	4122.77	4017.19	4235.14	3746.04	1819.12
100	2260.98	2686.38	2390.46	2341.47	2692.58	2172.02	914.86
101	1649.52	1975.21	1721.10	1674.54	1759.48	1563.83	764.00
102	1706.40	1815.93	1574.21	1539.50	1636.45	1430.36	684.39

Table 4.5 Percentage Error shown by various existing Empirical correlations for the Field trial test data

SL.NO.	MEASURED TUBING HEAD PRESSURE psi	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
1	1649.52	9.83	1.24	-5.81	-7.74	-8.01	-48.73
2	1649.52	4.77	-3.97	-10.15	-10.86	-12.74	-52.47
3	1649.52	13.92	4.83	-2.31	-3.94	-4.75	-47.27
4	1649.52	8.39	0.05	-7.05	-9.24	-9.09	-49.04
5	1649.52	7.04	-1.75	-8.20	-9.21	-10.73	-51.09
6	1350.90	-0.88	-8.21	-14.99	-17.57	-16.60	-52.65
7	1649.52	2.69	-5.31	-11.94	-13.80	-13.96	-51.97
8	1749.06	0.44	-8.40	-13.87	-13.57	-16.77	-55.58
9	1749.06	19.48	7.19	2.47	6.74	-2.61	-51.39
10	1749.06	3.64	-7.37	-11.67	-10.01	-15.84	-56.42
11	1749.06	19.48	7.19	2.47	6.74	-2.61	-51.39
12	1749.06	13.26	3.21	-2.16	1.99	-6.22	-53.09
13	1749.06	17.00	7.14	1.07	4.22	-2.65	-50.34
14	1749.06	12.17	4.26	-3.10	-3.41	-5.27	-48.64
15	1649.52	-1.64	-10.29	-15.03	-11.58	-18.49	-59.09
16	1649.52	-2.23	-7.23	-15.54	-19.64	-15.70	-50.30
17	298.62	26.64	6.42	6.41	16.10	-3.31	-56.05
18	298.62	31.54	10.75	10.53	20.07	0.63	-53.91
19	2104.56	21.50	5.45	4.20	16.95	-4.18	-58.18
20	2573.82	22.23	5.64	5.59	24.05	-4.01	-61.27
21	2573.82	3.76	-9.51	-10.36	3.22	-17.78	-65.61
22	2516.94	13.52	-0.78	-1.93	12.34	-9.84	-61.94
23	2516.94	9.24	-4.09	-5.63	7.03	-12.86	-62.54
24	2602.26	19.76	5.96	3.45	15.28	-3.72	-57.28
25	2602.26	10.09	-5.06	-4.90	12.30	-13.74	-65.51
26	2602.26	29.09	10.44	11.51	34.08	0.35	-61.16
27	2346.30	9.11	-7.26	-5.75	14.99	-15.73	-68.23
28	1194.48	1.52	-2.58	-12.94	-22.11	-11.49	-41.92
29	1194.48	0.27	-0.08	-12.60	-22.19	-9.21	-39.42
30	1350.90	29.36	8.74	7.90	13.44	-1.19	-52.17
31	1834.38	16.94	1.66	0.29	12.16	-7.63	-59.42
32	2502.72	14.73	4.82	0.00	8.32	-4.76	-55.34
33	2502.72	5.23	-9.07	-9.10	6.85	-17.38	-66.69
34	1137.60	10.30	2.90	-5.40	-9.79	-6.51	-45.31
35	1194.48	5.05	-2.00	-9.91	-14.09	-10.96	-47.91

Table 4.5 Percentage Error shown by various existing Empirical correlations for the Field trial test data

SL.NO.	MEASURED TUBING HEAD PRESSURE psi	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
36	2033.46	18.42	6.10	1.56	6.11	-3.60	-52.14
37	2090.34	13.03	1.64	-3.07	0.42	-7.64	-53.45
38	2133.00	2.06	-4.15	-11.04	-9.45	-12.91	-54.32
39	2133.00	10.00	-1.06	-5.67	-2.32	-10.10	-54.65
40	2133.00	-0.08	-6.48	-12.91	-10.67	-15.03	-56.04
41	1962.36	17.64	6.01	0.89	4.03	-3.68	-51.04
42	1962.36	10.92	-0.19	-4.87	-1.59	-9.31	-54.18
43	2403.18	1.01	-8.98	-11.96	-1.62	-17.29	-63.33
44	2417.40	11.58	-3.72	-4.31	8.84	-12.52	-62.72
45	2417.40	16.53	0.31	-0.07	14.29	-8.86	-61.54
46	2417.40	20.86	4.39	3.65	17.65	-5.15	-59.44
47	2133.00	15.22	-4.17	-1.19	22.11	-12.93	-68.04
48	2388.96	13.25	-0.69	-2.88	6.52	-9.77	-58.95
49	1493.10	31.11	13.76	10.63	14.65	3.36	-48.36
50	2531.16	15.28	-1.45	-1.14	14.83	-10.45	-63.26
51	2573.82	19.63	2.25	2.60	19.23	-7.09	-61.91
52	1251.36	9.79	1.62	-5.85	-8.63	-7.66	-47.66
53	1350.90	6.06	-1.71	-9.60	-15.15	-10.69	-46.41
54	952.74	21.15	3.44	1.79	7.14	-6.01	-54.42
55	1606.86	13.92	5.21	-2.90	-8.14	-4.40	-43.44
56	1606.86	13.92	5.21	-2.90	-8.14	-4.40	-43.44
57	1606.86	13.92	5.21	-2.90	-8.14	-4.40	-43.44
58	1606.86	10.32	1.27	-5.97	-9.82	-7.98	-46.88
59	1606.86	11.41	2.65	-4.46	-6.30	-6.73	-48.12
60	1606.86	11.41	2.65	-4.46	-6.30	-6.73	-48.12
61	1564.20	13.89	5.72	-2.33	-5.83	-3.94	-44.90
62	1649.52	14.77	1.20	-2.70	-0.47	-8.05	-52.86
63	1649.52	24.43	10.92	6.05	8.68	0.78	-48.36
64	1350.90	8.23	3.48	-7.18	-16.30	-5.97	-39.19
65	1350.90	17.74	8.06	-0.19	-6.75	-1.81	-40.75
66	1350.90	21.16	9.38	2.72	-0.38	-0.61	-43.92
67	995.40	7.25	-0.15	-8.02	-11.90	-9.27	-47.35
68	2630.70	23.17	7.09	7.35	30.08	-2.69	-62.69
69	1564.20	3.47	-7.28	-12.28	-13.49	-15.75	-53.87
70	1805.94	12.64	3.56	-3.40	-4.80	-5.91	-48.12

Table 4.5 Percentage Error shown by various existing Empirical correlations for the Field trial test data

SL.NO.	MEASURED TUBING HEAD PRESSURE psi	GILBERT	ROS	BAXENDELL	ACHONG	MACH	PILEHVARI
71	1493.10	13.47	4.81	-2.69	-5.13	-4.76	-46.46
72	1393.56	8.33	-0.95	-7.10	-7.30	-10.00	-51.47
73	1493.10	16.07	6.90	1.17	7.63	-2.86	-52.94
74	2104.56	19.46	6.89	4.12	18.23	-2.87	-58.15
75	981.18	18.63	4.02	1.73	11.59	-5.49	-57.01
76	981.18	17.34	2.19	0.63	12.09	-7.15	-58.92
77	995.40	22.79	6.05	5.30	19.52	-3.64	-58.78
78	995.40	20.55	6.43	3.38	11.63	-3.29	-54.76
79	1948.14	16.66	6.54	0.04	0.08	-3.19	-48.04
80	1877.04	13.22	-0.06	-4.01	-2.04	-9.20	-53.25
81	1877.04	17.90	3.66	-0.05	2.92	-5.82	-52.28
82	1877.04	11.23	-4.25	-6.15	-0.98	-13.00	-57.90
83	1905.48	29.95	9.69	9.19	17.92	-0.34	-53.87
84	1777.50	26.16	8.33	6.46	12.97	-1.57	-52.87
85	2943.54	45.30	17.37	23.18	53.62	6.65	-61.71
86	2943.54	19.20	-0.92	2.23	26.53	-9.97	-67.05
87	2943.54	28.85	7.81	10.50	34.75	-2.04	-63.17
88	3000.42	29.77	10.83	12.11	35.32	0.71	-61.30
89	3000.42	25.58	5.90	7.70	29.02	-3.78	-62.65
90	4194.90	11.59	0.04	-4.89	-3.75	-9.10	-52.35
91	4294.44	9.65	-0.32	-5.96	-4.93	-9.43	-52.30
92	4294.44	9.65	-0.32	-5.96	-4.93	-9.43	-52.30
93	4294.44	9.65	-0.32	-5.96	-4.93	-9.43	-52.30
94	3896.28	9.46	-1.35	-7.20	-9.66	-10.37	-49.77
95	3796.74	20.47	5.09	1.65	4.07	-4.51	-51.23
96	3995.82	18.59	3.18	0.53	5.99	-6.25	-54.47
97	3995.82	18.59	3.18	0.53	5.99	-6.25	-54.47
98	3995.82	18.59	3.18	0.53	5.99	-6.25	-54.47
99	3995.82	18.59	3.18	0.53	5.99	-6.25	-54.47
100	2260.98	18.81	5.73	3.56	19.09	-3.93	-59.54
101	1649.52	19.74	4.34	1.52	6.67	-5.20	-53.68
102	1706.40	6.42	-7.75	-9.78	-4.10	-16.18	-59.89

TABLE 4.6 STATISTICAL ACCURACY OF EMPIRAL CORRELATIONS FOR TUBINGHEAD PRESSURE PREDICTION

SL.NO	CORRELATION	AVERAGE PERCENT RELATIVE ERROR	AVERAGE ABSOLUTE PERCENT RELATIVE ERROR	MINIMUM ABSOLUTE PERCENT ERROR	MAXIMUM ABSOLUTE PERCENT ERROR	STANDARD DEVIATION	CORRELATION COEFFICIENT
1	GILBERT	14.33	14.42	0.085	45.3	16.28	0.9966
2	ROS	1.82	4.8	0.038	17.37	5.75	0.9995
3	BAXENDELL	-2.1	5.7	0.004	23.18	7.45	0.9993
4	ACHONG	3.4	11.4	0.082	53.62	14.32	0.9975
5	MACH	-7.49	7.7	0.337	18.49	9.5	0.999
6	PILEHVARI	-54.07	54.07	39.17	68.23	55.22	0.9636
7	PRESENT	0.89	4.59	0.18	16.9	5.52	0.99998

TABLE 4.7 SURFACE CHOKE FLOW RATE PREDICTION BY THE PRESENT THEORETICAL MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	RELATIVE PERCENT ERROR
1	565.50	476.38	-15.76
2	504.40	466.93	-7.43
3	574.90	473.59	-17.62
4	567.40	478.58	-15.65
5	524.00	469.27	-10.44
6	441.00	424.98	-3.63
7	531.00	476.95	-10.18
8	483.00	476.10	-1.43
9	572.00	443.69	-22.43
10	642.00	637.59	-0.69
11	472.00	442.83	-6.18
12	301.00	301.85	0.28
13	330.00	309.03	-6.35
14	377.40	329.66	-12.65
15	249.00	290.56	16.69
16	396.30	340.80	-14.00
17	201.00	269.77	34.21
18	213.90	274.52	28.34
19	391.00	428.46	9.58
20	255.00	298.43	17.03
21	241.00	316.44	31.30
22	265.00	315.41	19.02
23	269.00	324.33	20.57
24	334.00	347.89	4.16
25	226.00	296.23	31.08
26	242.00	279.67	15.57
27	171.00	243.81	42.58
28	610.00	438.51	-28.11
29	258.00	193.07	-25.17
30	1673.00	1555.68	-7.01
31	334.00	385.93	15.55
32	221.00	224.71	1.68
33	213.00	288.65	35.52
34	451.00	390.66	-13.38
35	451.00	403.17	-10.61

TABLE 4.7 SURFACE CHOKE FLOW RATE PREDICTION BY THE PRESENT THEORETICAL MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	RELATIVE PERCENT ERROR
36	535.00	493.29	-7.80
37	550.00	510.37	-7.21
38	232.00	230.34	-0.72
39	547.00	517.70	-5.36
40	218.00	227.17	4.21
41	550.00	486.82	-11.49
42	510.00	490.47	-3.83
43	159.00	203.31	27.87
44	384.00	459.70	19.71
45	390.00	452.96	16.14
46	421.00	462.20	9.79
47	226.00	318.09	40.75
48	446.70	498.03	11.49
49	1088.00	954.05	-12.31
50	372.00	451.19	21.29
51	392.00	456.32	16.41
52	450.00	406.40	-9.69
53	780.00	615.90	-21.04
54	742.00	834.95	12.53
55	956.00	675.17	-29.38
56	956.00	675.17	-29.38
57	956.00	675.64	-29.33
58	862.00	665.04	-22.85
59	555.00	469.84	-15.34
60	555.00	470.08	-15.30
61	604.00	473.82	-21.55
62	874.00	818.23	-6.38
63	704.00	611.74	-13.11
64	705.00	468.98	-33.48
65	1183.00	822.62	-30.46
66	1000.00	785.95	-21.41
67	375.00	358.17	-4.49
68	138.00	194.37	40.85
69	906.00	832.49	-8.11
70	615.00	502.21	-18.34

TABLE 4.7 SURFACE CHOKE FLOW RATE PREDICTION BY THE PRESENT THEORETICAL MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	RELATIVE PERCENT ERROR
71	542.00	454.76	-16.10
72	428.00	418.51	-2.22
73	147.00	162.63	10.63
74	151.00	176.14	16.65
75	201.00	252.18	25.46
76	183.00	239.48	30.86
77	176.00	227.01	28.98
78	225.00	268.17	19.19
79	635.00	516.16	-18.71
80	994.00	895.85	-9.87
81	988.00	876.87	-11.25
82	1057.00	1079.64	2.14
83	1390.00	1304.65	-6.14
84	1101.00	1031.56	-6.31
85	698.00	1226.01	75.65
86	320.00	585.80	83.06
87	375.00	645.04	72.01
88	274.00	455.17	66.12
89	409.00	480.75	17.54
90	1717.00	1097.96	-36.05
91	1245.00	812.90	-34.71
92	1245.00	813.07	-34.69
93	1245.00	812.77	-34.72
94	2554.00	1242.83	-51.34
95	2459.00	1714.79	-30.26
96	1868.00	1353.85	-27.52
97	1869.00	1354.07	-27.55
98	1868.00	1353.94	-27.52
99	1869.00	1353.62	-27.58
100	151.00	181.86	20.44
101	793.00	784.53	-1.07
102	686.00	778.77	13.52

TABLE. 4.8 SURFACE CHOKE FLOW RATE PREDICTION BY OMANA'S MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.50	509.28	9.94
2	504.40	469.74	6.87
3	574.90	496.99	13.55
4	567.40	519.31	8.48
5	524.00	479.04	8.58
6	441.00	286.83	34.96
7	531.00	511.74	3.63
8	483.00	526.42	-8.99
9	572.00	415.83	27.30
10	642.00	661.92	-3.10
11	472.00	415.83	11.90
12	301.00	282.17	6.26
13	330.00	302.26	8.41
14	377.40	374.38	0.80
15	249.00	236.92	4.85
16	396.30	417.35	-5.31
17	201.00	3.28	98.37
18	213.90	3.37	98.43
19	391.00	468.73	-19.88
20	255.00	454.78	-78.35
21	241.00	516.27	-114.22
22	265.00	496.63	-87.41
23	269.00	529.04	-96.67
24	334.00	657.60	-96.89
25	226.00	455.89	-101.72
26	242.00	406.82	-68.11
27	171.00	266.54	-55.87
28	610.00	322.45	47.14
29	258.00	141.79	45.04
30	1673.00	746.21	55.40
31	334.00	308.99	7.49
32	221.00	434.15	-96.45
33	213.00	414.13	-94.43
34	451.00	184.43	59.11
35	451.00	214.97	52.33

TABLE. 4.8 SURFACE CHOKE FLOW RATE PREDICTION BY OMANA'S MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535.00	659.64	-23.30
37	550.00	760.12	-38.20
38	232.00	386.62	-66.65
39	547.00	813.42	-48.71
40	218.00	368.38	-68.98
41	550.00	610.79	-11.05
42	510.00	626.61	-22.87
43	159.00	313.56	-97.21
44	384.00	669.89	-74.45
45	390.00	647.12	-65.93
46	421.00	678.58	-61.18
47	226.00	266.11	-17.75
48	446.70	812.43	-81.87
49	1088.00	613.98	43.57
50	372.00	679.64	-82.70
51	392.00	713.91	-82.12
52	450.00	223.25	50.39
53	780.00	486.39	37.64
54	742.00	165.94	77.64
55	956.00	806.30	15.66
56	956.00	806.30	15.66
57	956.00	806.30	15.66
58	862.00	739.85	14.17
59	555.00	463.58	16.47
60	555.00	464.70	16.27
61	604.00	474.62	21.42
62	874.00	716.17	18.06
63	704.00	529.69	24.76
64	705.00	452.52	35.81
65	1183.00	670.76	43.30
66	1000.00	529.93	47.01
67	375.00	116.83	68.85
68	138.00	316.35	-129.24
69	906.00	753.76	16.80
70	615.00	653.68	-6.29
71	542.00	381.44	29.62

TABLE. 4.8 SURFACE CHOKE FLOW RATE PREDICTION BY OMANA'S MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
72	428.00	264.11	38.29
73	147.00	93.78	36.21
74	151.00	185.80	-23.05
75	201.00	47.47	76.39
76	183.00	43.06	76.47
77	176.00	40.02	77.26
78	225.00	54.81	75.64
79	635.00	757.39	-19.27
80	994.00	1096.79	-10.34
81	988.00	1036.38	-4.90
82	1057.00	1138.56	-7.72
83	1390.00	1283.93	7.63
84	1101.00	922.89	16.18
85	698.00	5896.00	-744.70
86	320.00	1627.59	-408.62
87	375.00	2396.96	-539.19
88	274.00	1908.75	-596.62
89	409.00	993.29	-142.86
90	1717.00	11258.15	-555.69
91	1245.00	8817.99	-608.27
92	1245.00	8804.89	-607.22
93	1245.00	8804.89	-607.22
94	2554.00	15167.67	-493.88
95	2459.00	13026.93	-429.77
96	1868.00	9946.28	-432.46
97	1869.00	9946.28	-432.17
98	1868.00	9946.28	-432.46
99	1869.00	9946.28	-432.17
100	151.00	215.20	-42.52
101	793.00	604.53	23.77
102	686.00	625.16	8.87

TABLE 4.9 SURFACE CHOKE FLOWRATE PREDICTION BY POETTMANN AND BECK MODEL

SL. NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.50	780.45	-38.01
2	504.40	687.12	-36.22
3	574.90	751.13	-30.65
4	567.40	804.57	-41.80
5	524.00	708.78	-35.26
6	441.00	817.41	-85.35
7	531.00	786.20	-48.06
8	483.00	619.17	-28.19
9	572.00	421.12	26.38
10	642.00	782.76	-21.93
11	472.00	422.84	10.42
12	301.00	265.82	11.69
13	330.00	297.73	9.78
14	377.40	422.32	-11.90
15	249.00	268.64	-7.89
16	396.30	662.77	-67.24
17	201.00	579.67	-188.39
18	213.90	598.23	-179.68
19	391.00	192.85	50.68
20	255.00	76.56	69.98
21	241.00	94.30	60.87
22	265.00	99.53	62.44
23	269.00	110.40	58.96
24	334.00	133.09	60.15
25	226.00	72.74	67.81
26	242.00	60.49	75.00
27	171.00	52.04	69.57
28	610.00	1555.02	-154.92
29	258.00	615.77	-138.67
30	1673.00	2103.28	-25.72
31	334.00	201.34	39.72
32	221.00	103.76	53.05
33	213.00	77.19	63.76
34	451.00	899.79	-99.51
35	451.00	915.41	-102.97

TABLE 4.9 SURFACE CHOKE FLOWRATE PREDICTION BY POETTMANN AND BECK MODEL

SL. NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535.00	408.35	23.67
37	550.00	448.09	18.53
38	232.00	195.21	15.86
39	547.00	451.19	17.52
40	218.00	179.95	17.45
41	550.00	432.37	21.39
42	510.00	451.24	11.52
43	159.00	73.45	53.81
44	384.00	168.81	56.04
45	390.00	159.41	59.12
46	421.00	172.46	59.04
47	226.00	71.82	68.22
48	446.70	248.19	44.44
49	1088.00	1183.63	-8.79
50	372.00	134.89	63.74
51	392.00	134.22	65.76
52	450.00	784.79	-74.40
53	780.00	1584.84	-103.18
54	742.00	1179.94	-59.02
55	956.00	1572.63	-64.50
56	956.00	1572.63	-64.50
57	956.00	1565.71	-63.78
58	862.00	1378.08	-59.87
59	555.00	757.06	-36.41
60	555.00	757.68	-36.52
61	604.00	887.63	-46.96
62	874.00	1029.14	-17.75
63	704.00	716.12	-1.72
64	705.00	1529.51	-116.95
65	1183.00	2290.70	-93.64
66	1000.00	1480.52	-48.05
67	375.00	811.31	-116.35
68	138.00	45.65	66.92
69	906.00	1435.20	-58.41
70	615.00	740.33	-20.38

TABLE 4.9 SURFACE CHOKE FLOWRATE PREDICTION BY POETTMANN AND BECK MODEL

SL. NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
71	542.00	780.88	-44.07
72	428.00	610.64	-42.67
73	147.00	116.89	20.48
74	151.00	61.22	59.46
75	201.00	222.12	-10.51
76	183.00	190.47	-4.08
77	176.00	158.42	9.99
78	225.00	259.73	-15.43
79	635.00	640.78	-0.91
80	994.00	1071.15	-7.76
81	988.00	997.76	-0.99
82	1057.00	1016.54	3.83
83	1390.00	1021.63	26.50
84	1101.00	943.14	14.34
85	698.00	1674.24	-139.86
86	320.00	256.59	19.82
87	375.00	496.68	-32.45
88	274.00	375.38	-37.00
89	409.00	102.86	74.85
90	1717.00	856.66	50.11
91	1245.00	597.88	51.98
92	1245.00	593.36	52.34
93	1245.00	596.77	52.07
94	2554.00	1907.61	25.31
95	2459.00	1467.07	40.34
96	1868.00	804.24	56.95
97	1869.00	803.46	57.01
98	1868.00	804.18	56.95
99	1869.00	805.03	56.93
100	151.00	52.68	65.11
101	793.00	765.37	3.48
102	686.00	692.22	-0.91

TABLE 4.10 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.50	609.59	-7.80
2	504.40	590.86	-17.14
3	574.90	604.03	-5.07
4	567.40	613.96	-8.21
5	524.00	595.49	-13.64
6	441.00	547.50	-24.15
7	531.00	610.70	-15.01
8	483.00	595.74	-23.34
9	572.00	532.54	6.90
10	642.00	790.79	-23.18
11	472.00	530.90	-12.48
12	301.00	357.40	-18.74
13	330.00	370.99	-12.42
14	377.40	410.97	-8.89
15	249.00	345.50	-38.75
16	396.30	442.34	-11.62
17	201.00	321.07	-59.74
18	213.90	327.30	-53.02
19	391.00	448.55	-14.72
20	255.00	257.85	-1.12
21	241.00	291.93	-21.13
22	265.00	297.01	-12.08
23	269.00	314.28	-16.83
24	334.00	351.35	-5.19
25	226.00	250.75	-10.95
26	242.00	221.36	8.53
27	171.00	188.65	-10.32
28	610.00	595.00	2.46
29	258.00	260.05	-0.80
30	1673.00	1922.98	-14.94
31	334.00	412.98	-23.65
32	221.00	237.47	-7.45
33	213.00	251.10	-17.89
34	451.00	508.76	-12.81
35	451.00	525.53	-16.53

TABLE 4.10 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535.00	588.90	-10.08
37	550.00	615.72	-11.95
38	232.00	276.59	-19.22
39	547.00	624.37	-14.14
40	218.00	269.80	-23.76
41	550.00	586.74	-6.68
42	510.00	594.31	-16.53
43	159.00	200.77	-26.27
44	384.00	456.66	-18.92
45	390.00	443.48	-13.71
46	421.00	461.58	-9.64
47	226.00	250.29	-10.75
48	446.70	539.29	-20.73
49	1088.00	1189.31	-9.31
50	372.00	417.89	-12.34
51	392.00	420.39	-7.24
52	450.00	526.79	-17.06
53	780.00	825.44	-5.83
54	742.00	1036.75	-39.72
55	956.00	897.10	6.16
56	956.00	897.10	6.16
57	956.00	897.65	6.10
58	862.00	875.56	-1.57
59	555.00	604.33	-8.89
60	555.00	604.66	-8.95
61	604.00	618.35	-2.38
62	874.00	1025.40	-17.32
63	704.00	759.83	-7.93
64	705.00	639.73	9.26
65	1183.00	1110.13	6.16
66	1000.00	3148.82	-214.88
67	375.00	468.67	-24.98
68	138.00	163.06	-18.16
69	906.00	1082.18	-19.45
70	615.00	642.65	-4.50

TABLE 4.10 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
71	542.00	591.26	-9.09
72	428.00	533.24	-24.59
73	147.00	187.07	-27.26
74	151.00	170.67	-13.03
75	201.00	292.14	-45.34
76	183.00	272.45	-48.88
77	176.00	251.76	-43.04
78	225.00	316.24	-40.55
79	635.00	651.34	-2.57
80	994.00	1125.23	-13.20
81	988.00	1087.76	-10.10
82	1057.00	1313.39	-24.26
83	1390.00	1551.90	-11.65
84	1101.00	1249.90	-13.52
85	698.00	1591.66	-128.03
86	320.00	624.40	-95.12
87	375.00	776.38	-107.04
88	274.00	550.99	-101.09
89	409.00	388.14	5.10
90	1717.00	1332.06	22.42
91	1245.00	971.08	22.00
92	1245.00	972.07	21.92
93	1245.00	971.17	21.99
94	2554.00	1835.63	28.13
95	2459.00	2103.11	14.47
96	1868.00	1548.10	17.13
97	1869.00	1548.45	17.15
98	1868.00	1548.19	17.12
99	1869.00	1547.74	17.19
100	151.00	166.64	-10.36
101	793.00	959.60	-21.01
102	686.00	933.79	-36.12

TABLE 4.11 SURFACE CHOKE FLOW RATE PREDICTION BY SACHDEVA'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREEDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.50	385.34	31.86
2	504.40	352.83	30.05
3	574.90	375.12	34.75
4	567.40	393.78	30.60
5	524.00	360.37	31.23
6	441.00	402.28	8.78
7	531.00	387.29	27.06
8	483.00	329.03	31.88
9	572.00	259.56	54.62
10	642.00	427.38	33.43
11	472.00	260.45	44.82
12	301.00	170.85	43.24
13	330.00	182.55	44.68
14	377.40	226.34	40.03
15	249.00	171.23	31.23
16	396.30	310.80	21.57
17	201.00	275.73	-37.18
18	213.90	284.18	-32.86
19	391.00	170.95	56.28
20	255.00	90.98	64.32
21	241.00	101.00	58.09
22	265.00	103.63	60.89
23	269.00	109.15	59.42
24	334.00	120.19	64.02
25	226.00	88.79	60.71
26	242.00	81.00	66.53
27	171.00	74.45	56.46
28	610.00	734.69	-20.44
29	258.00	288.78	-11.93
30	1673.00	1178.93	29.53
31	334.00	173.21	48.14
32	221.00	85.49	61.31
33	213.00	91.57	57.01
34	451.00	438.28	2.82
35	451.00	443.50	1.66

TABLE 4.11 SURFACE CHOKE FLOW RATE PREDICTION BY SACHDEVA'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREEDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535.00	255.09	52.32
37	550.00	269.10	51.07
38	232.00	118.61	48.88
39	547.00	270.23	50.60
40	218.00	113.28	48.04
41	550.00	263.35	52.12
42	510.00	269.95	47.07
43	159.00	71.11	55.27
44	384.00	161.28	58.00
45	390.00	156.67	59.83
46	421.00	163.04	61.27
47	226.00	103.75	54.09
48	446.70	196.48	56.02
49	1088.00	663.71	39.00
50	372.00	144.20	61.24
51	392.00	144.00	63.26
52	450.00	390.59	13.20
53	780.00	731.96	6.16
54	742.00	680.79	8.25
55	956.00	711.92	25.53
56	956.00	711.92	25.53
57	956.00	706.21	26.13
58	862.00	636.35	26.18
59	555.00	376.41	32.18
60	555.00	376.62	32.14
61	604.00	422.95	29.98
62	874.00	559.34	36.00
63	704.00	401.79	42.93
64	705.00	697.17	1.11
65	1183.00	1044.12	11.74
66	1000.00	670.70	32.93
67	375.00	402.48	-7.33
68	138.00	56.02	59.40
69	906.00	695.49	23.24
70	615.00	369.20	39.97

TABLE 4.11 SURFACE CHOKE FLOW RATE PREDICTION BY SACHDEVA'S MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREEDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
71	542.00	385.18	28.93
72	428.00	324.27	24.24
73	147.00	86.69	41.03
74	151.00	63.95	57.65
75	201.00	163.08	18.87
76	183.00	148.92	18.63
77	176.00	134.51	23.57
78	225.00	179.81	20.09
79	635.00	334.43	47.33
80	994.00	571.77	42.48
81	988.00	555.89	43.74
82	1057.00	607.28	42.55
83	1390.00	663.10	52.29
84	1101.00	579.31	47.38
85	698.00	745.25	-6.77
86	320.00	199.72	37.59
87	375.00	283.24	24.47
88	274.00	208.36	23.96
89	409.00	126.97	68.96
90	1717.00	439.79	74.39
91	1245.00	315.91	74.63
92	1245.00	313.94	74.78
93	1245.00	315.42	74.66
94	2554.00	823.60	67.75
95	2459.00	755.48	69.28
96	1868.00	485.97	73.98
97	1869.00	485.55	74.02
98	1868.00	485.92	73.99
99	1869.00	486.40	73.98
100	151.00	59.28	60.74
101	793.00	463.21	41.59
102	686.00	439.40	35.95

TABLE 4.12 SURFACE CHOKE FLOW RATE PREDICTION BY PERKINS' MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.50	867.08	-53.33
2	504.40	790.53	-56.73
3	574.90	843.48	-46.72
4	567.40	886.20	-56.19
5	524.00	808.68	-54.33
6	441.00	1035.90	-134.90
7	531.00	874.87	-64.76
8	483.00	703.67	-45.69
9	572.00	522.45	8.66
10	642.00	927.08	-44.40
11	472.00	535.93	-13.55
12	301.00	343.24	-14.03
13	330.00	376.54	-14.10
14	377.40	493.81	-30.85
15	249.00	359.66	-44.44
16	396.30	711.70	-79.59
17	201.00	2881.07	-1333.37
18	213.90	2987.92	-1296.88
19	391.00	213.27	45.45
20	255.00	74.04	70.97
21	241.00	92.96	61.43
22	265.00	99.90	62.30
23	269.00	110.72	58.84
24	334.00	130.75	60.85
25	226.00	69.78	69.12
26	242.00	56.61	76.61
27	171.00	50.22	70.63
28	610.00	1574.65	-158.14
29	258.00	645.84	-150.32
30	1673.00	2743.01	-63.96
31	334.00	240.47	28.00
32	221.00	102.37	53.68
33	213.00	75.50	64.55
34	451.00	1191.93	-164.29
35	451.00	1161.90	-157.63

TABLE 4.12 SURFACE CHOKE FLOW RATE PREDICTION BY PERKINS' MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535.00	403.03	24.67
37	550.00	426.48	22.46
38	232.00	184.52	20.46
39	547.00	423.42	22.59
40	218.00	172.98	20.65
41	550.00	431.26	21.59
42	510.00	446.00	12.55
43	159.00	77.24	51.42
44	384.00	176.95	53.92
45	390.00	167.05	57.17
46	421.00	180.75	57.07
47	226.00	71.08	68.55
48	446.70	245.74	44.99
49	1088.00	1338.90	-23.06
50	372.00	129.75	65.12
51	392.00	127.90	67.37
52	450.00	875.12	-94.47
53	780.00	1359.26	-74.26
54	742.00	1948.67	-162.62
55	956.00	1295.36	-35.50
56	956.00	1295.36	-35.50
57	956.00	1359.11	-42.17
58	862.00	1241.03	-43.97
59	555.00	744.07	-34.07
60	555.00	744.06	-34.07
61	604.00	848.22	-40.43
62	874.00	1080.39	-23.61
63	704.00	767.70	-9.05
64	705.00	1256.24	-78.19
65	1183.00	2022.31	-70.95
66	1000.00	1641.33	-64.13
67	375.00	1075.85	-186.89
68	138.00	40.77	70.45
69	906.00	1508.79	-66.53
70	615.00	660.01	-7.32

TABLE 4.12 SURFACE CHOKE FLOW RATE PREDICTION BY PERKINS' MODEL

SL.NO.	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
71	542.00	692.86	-27.83
72	428.00	608.32	-42.13
73	147.00	141.76	3.56
74	151.00	65.97	56.31
75	201.00	340.86	-69.58
76	183.00	304.71	-66.51
77	176.00	249.91	-41.99
78	225.00	406.81	-80.80
79	635.00	539.04	15.11
80	994.00	998.08	-0.41
81	988.00	711.28	28.01
82	1057.00	1014.47	4.02
83	1390.00	992.59	28.59
84	1101.00	948.94	13.81
85	698.00	953.95	-36.67
86	320.00	192.95	39.70
87	375.00	342.65	8.63
88	274.00	251.65	8.16
89	409.00	87.48	78.61
90	1717.00	489.25	71.51
91	1245.00	371.23	70.18
92	1245.00	358.46	71.21
93	1245.00	368.00	70.44
94	2554.00	1009.58	60.47
95	2459.00	776.05	68.44
96	1868.00	529.96	71.63
97	1869.00	528.10	71.74
98	1868.00	530.38	71.61
99	1869.00	531.77	71.55
100	151.00	46.91	68.93
101	793.00	772.22	2.62
102	686.00	723.46	-5.46

TABLE 4.13 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD AND PIERCE MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	565.5	163.9825	71.0022
2	504.4	185.0085	63.32107
3	574.9	170.1058	70.41124
4	567.4	159.2336	71.93627
5	524	179.7083	65.70452
6	441	151.5641	65.63172
7	531	162.8843	69.325
8	483	204.558	57.64846
9	572	286.2991	49.94771
10	642	300.6438	53.17075
11	472	289.3116	38.70516
12	301	219.3683	27.12018
13	330	199.5519	39.52972
14	377.4	147.1575	61.00755
15	249	217.0801	12.81924
16	396.3	95.16746	75.98601
17	201	833.3418	-314.5979
18	213.9	808.2114	-277.8455
19	391	496.0997	-26.87971
20	255	479.5013	-88.03972
21	241	424.4365	-76.11472
22	265	413.2383	-55.93898
23	269	385.506	-43.31078
24	334	337.8977	-1.166987
25	226	493.5101	-118.3673
26	242	544.5187	-125.0077
27	171	602.1647	-252.1431
28	610	65.54497	89.25492
29	258	34.40031	86.66655
30	1673	929.8361	44.42104
31	334	503.5804	-50.77257
32	221	196.7901	10.9547
33	213	497.5323	-133.5833
34	451	128.5781	71.49045
35	451	128.1472	71.58598

TABLE 4.13 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD AND PIERCE MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
36	535	273.9437	48.79558
37	550	253.2434	53.95575
38	232	115.7283	50.1171
39	547	251.5279	54.01684
40	218	123.7881	43.21647
41	550	261.5448	52.4464
42	510	252.3093	50.52759
43	159	243.9265	-53.41289
44	384	534.5992	-39.21855
45	390	555.4044	-42.41139
46	421	526.9448	-25.16503
47	226	899.5162	-298.016
48	446.7	406.2189	9.062259
49	1088	493.2556	54.66401
50	372	597.9092	-60.72828
51	392	597.626	-52.45562
52	450	144.2534	67.94368
53	780	124.9783	83.97713
54	742	663.0641	10.63826
55	956	137.5433	85.61263
56	956	137.5433	85.61263
57	956	139.3037	85.42848
58	862	159.6186	81.48277
59	555	157.5275	71.61668
60	555	157.4092	71.63799
61	604	133.453	77.90513
62	874	365.2875	58.20509
63	704	299.726	57.42528
64	705	66.39287	90.58257
65	1183	148.4487	87.45151
66	1000	176.3624	82.36375
67	375	126.9882	66.13649
68	138	300.9024	-118.0452
69	906	256.0423	71.73926
70	615	162.1892	73.62777

TABLE 4.13 SURFACE CHOKE FLOW RATE PREDICTION BY ASHFORD AND PIERCE MODEL

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
71	542	142.1758	73.7683
72	428	178.5679	58.27852
73	147	170.1601	-15.7552
74	151	271.6832	-79.92263
75	201	414.3549	-106.1467
76	183	467.9657	-155.719
77	176	538.1017	-205.7396
78	225	366.2201	-62.7645
79	635	181.5653	71.40704
80	994	347.3852	65.0518
81	988	355.5388	64.01429
82	1057	562.6642	46.76781
83	1390	787.2266	43.36499
84	1101	585.9152	46.78336
85	698	208.541	70.12306
86	320	348.7983	-8.999472
87	375	208.6268	44.3662
88	274	139.2601	49.17516
89	409	655.166	-60.18729
90	1717	212.2596	87.63776
91	1245	173.5151	86.06304
92	1245	170.4834	86.30656
93	1245	172.7593	86.12375
94	2554	186.4776	92.69861
95	2459	343.952	86.01253
96	1868	404.5937	78.34081
97	1869	403.8239	78.39359
98	1868	404.7054	78.33483
99	1869	405.3503	78.31192
100	151	274.1016	-81.52423
101	793	442.8637	44.15338
102	686	504.0199	26.52771

TABLE 4.14 STATISTICAL ACCURACY OF THEORETICAL MODELS FOR FLOW RATE PREDICTION

SL.NO	MODEL	AVERAGE PERCENT RELATIVE ERROR	AVERAGE ABSOLUTE PERCENT RELATIVE ERROR	MINIMUM ABSOLUTE PERCENT ERROR	MAXIMUM ABSOLUTE PERCENT ERROR	STANDARD DEVIATION	CORRELATION COEFFICIENT
1	OMANA	-76.69	109.13	0.80	744.69	203.64	0.9120
2	POETTMANN AND BECK	-5.09	49.23	0.91	188.31	61.54	0.9927
3	ASHFORD	-16.98	22.01	0.80	214.90	36.01	0.9973
4	SACHDEVA	39.56	41.83	1.10	74.78	46.18	0.9908
5	PERKINS	-30.48	80.47	0.40	1333.40	193.28	0.9670
6	ASHFORD AND PIERCE	14.76	20.52	1.20	314.60	90.71	0.9717
7	PRESENT	19.90	20.71	0.28	83.06	25.20	0.9983

TABLE 4.15 FLOWRATE PREDICTION BY THE PRESENT THEORETICAL MODEL WITH ASHFORD AND PIERCE DATA

SL. NO	MEASURED FLOWRATE BBLS/DAY	PREDICTED FLOWRATE BBLS/DAY	RELATIVE PERCENT ERROR
1	1010.00	1260.37	-24.79
2	1010.00	324.77	67.84
3	1505.00	1305.28	13.27
4	1190.00	906.30	23.84
5	720.00	494.06	31.38
6	1340.00	1416.88	-5.74
7	1055.00	970.90	7.97
8	590.00	514.74	12.76
9	2088.00	1467.75	29.71
10	1752.00	999.32	42.96
11	1068.00	533.81	50.02
12	370.00	644.54	-74.20
13	350.00	424.88	-21.40
14	290.00	276.65	4.60
15	725.00	997.60	-37.60
16	575.00	646.17	-12.38
17	415.00	311.55	24.93
18	305.00	549.51	-80.17
19	295.00	347.27	-17.72
20	190.00	255.43	-34.44
21	3686.00	3226.61	12.46
22	3898.00	3263.43	16.28
23	4576.00	3793.66	17.10
24	4728.00	3888.75	17.75
25	2661.00	2148.89	19.24
26	2580.00	2273.63	11.87
27	2555.00	2244.89	12.14

TABLE 4.16 SURFACE CHOKE FLOW RATE PREDICTION BY THE PRESENT THEORETICAL MODEL WITH OMANA DATA

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
1	16.7	12.48	-25.26
2	19.4	12.88	-33.62
3	32.58	25.50	-21.74
4	34.96	37.05	5.98
5	52.69	30.88	-41.40
6	39.45	26.58	-32.63
7	39.29	26.25	-33.20
8	41.34	43.78	5.91
9	78.91	86.33	9.40
10	117.2	59.06	-49.60
11	76.74	48.62	-36.64
12	77.82	51.34	-34.03
13	78.9	82.21	4.20
14	158.3	162.29	2.52
15	240.5	110.06	-54.24
16	112.9	77.13	-31.68
17	115.1	124.74	8.37
18	222.6	245.37	10.23
19	341	170.96	-49.86
20	144.8	110.22	-23.88
21	143.8	109.79	-23.65
22	143.8	343.51	138.88
23	289.1	359.02	24.18
24	422.6	291.75	-30.96

TABLE 4.16 SURFACE CHOKE FLOW RATE PREDICTION BY THE PRESENT THEORETICAL MODEL WITH OMANA DATA

SL.NO	MEASURED FLOW RATE BBLS/DAY	PREDICTED FLOW RATE BBLS/DAY	PERCENT RELATIVE ERROR
25	170.8	193.32	13.18
26	171.9	222.94	29.69
27	337.3	307.29	-8.90
28	337.9	457.50	35.40
29	32.96	26.42	-19.83
30	31.83	25.51	-19.86
31	34.8	29.37	-15.61
32	39.45	36.12	-8.44
33	38.85	26.00	-33.07
34	35.18	28.95	-17.70
35	162.1	117.72	-27.38
36	155.6	112.01	-28.02
37	153.5	111.14	-27.60
38	143.2	105.85	-26.08
39	137.8	109.88	-20.26
40	139.9	133.79	-4.37
41	142.1	122.26	-13.96
42	285.9	255.42	-10.66
43	281	250.37	-10.90
44	272.9	246.67	-9.61
45	269.7	236.51	-12.31
46	249.7	269.94	8.10
47	212.3	292.57	37.81

FIGURES OF CHAPTER-IV

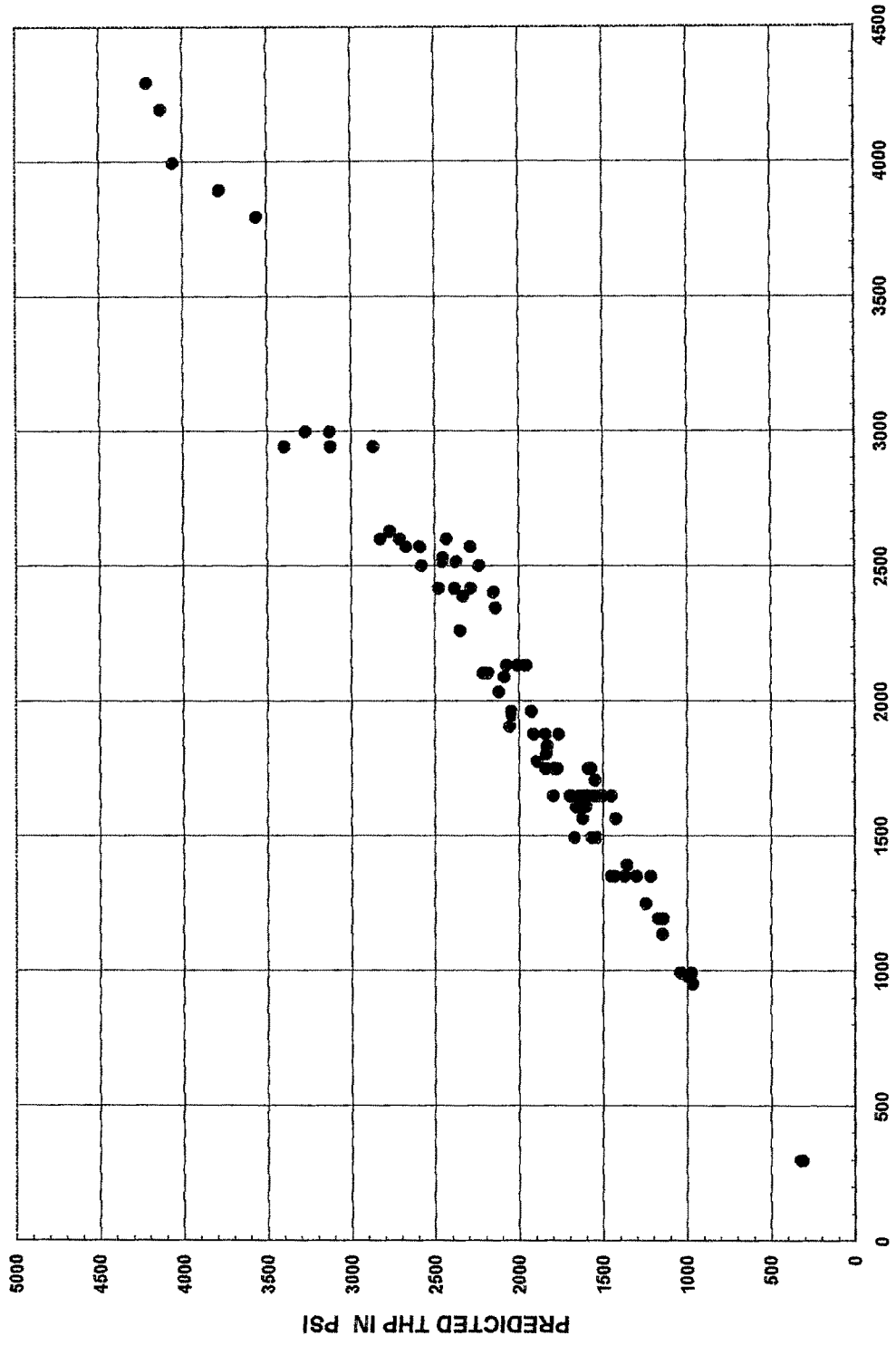


FIGURE 4.4 CROSS PLOT FOR TUBINGHEAD PRESSURE - PRESENT EMPIRICAL CORRELATION

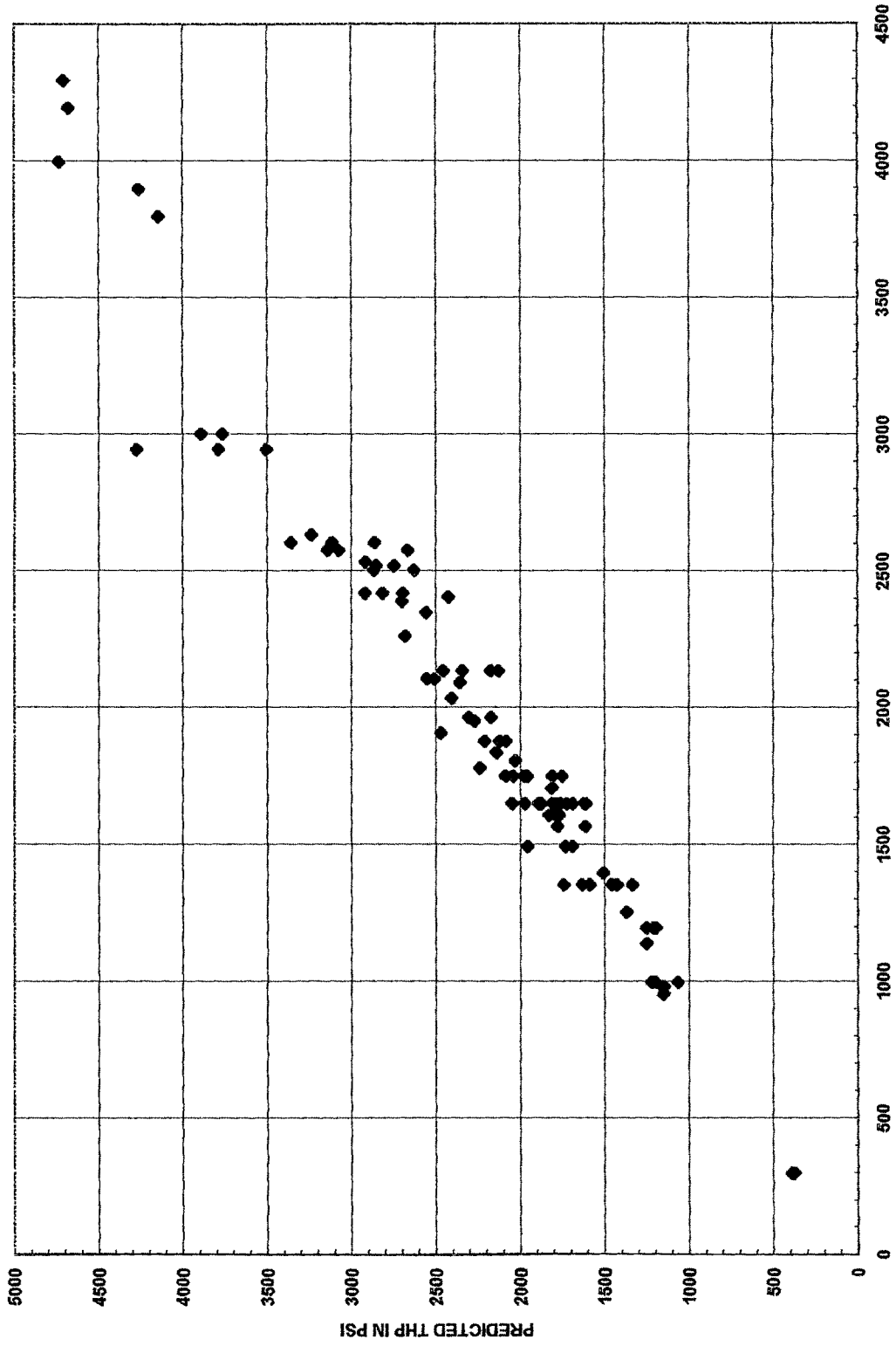


FIGURE 4.5 CROSS PLOT FOR TUBINGHEAD PRESSURE - GILBERT'S CORRELATION

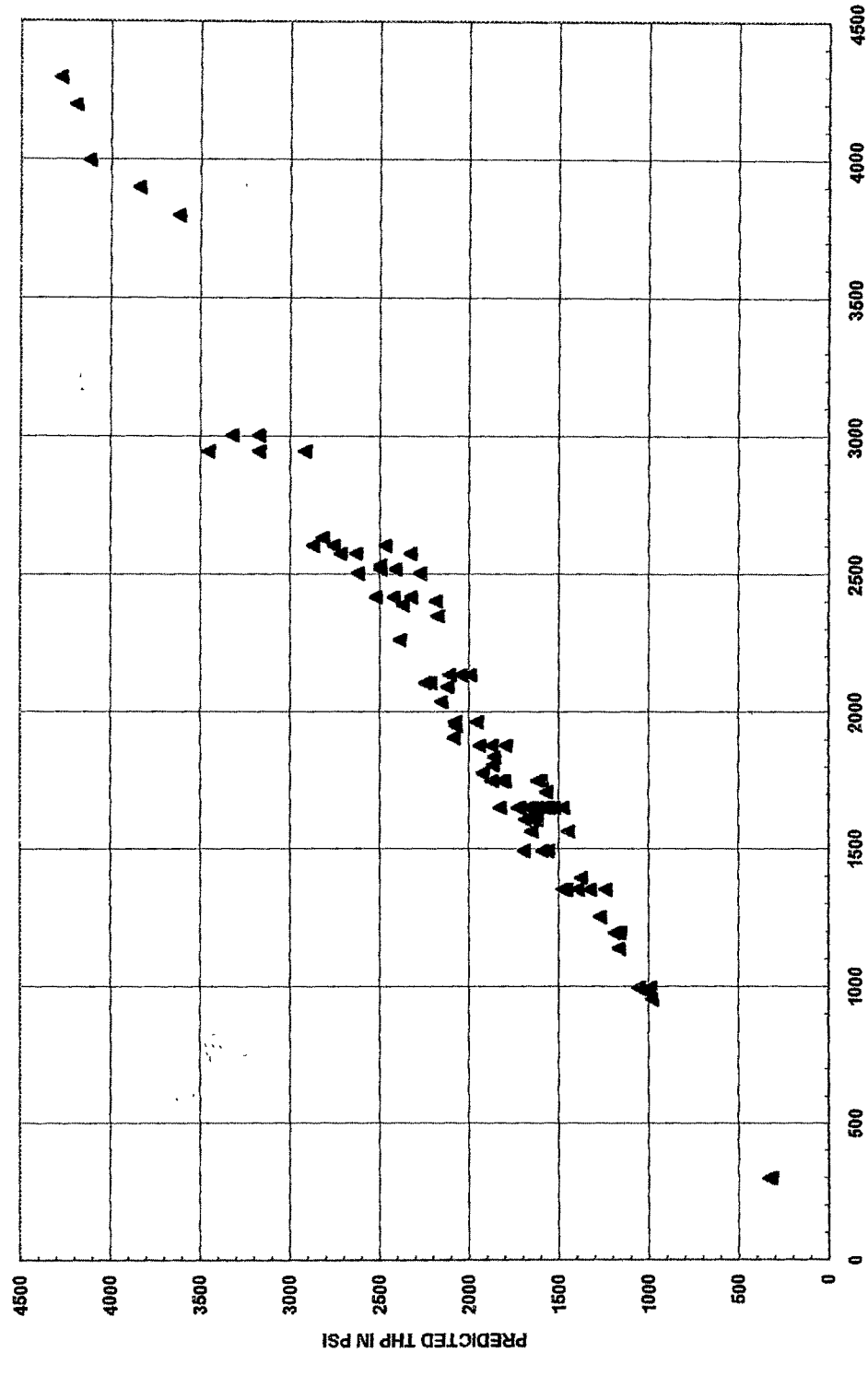


FIGURE 4.6 CROSS PLOT FOR TUBINGHEAD PRESSURE - ROS'S CORRELATION

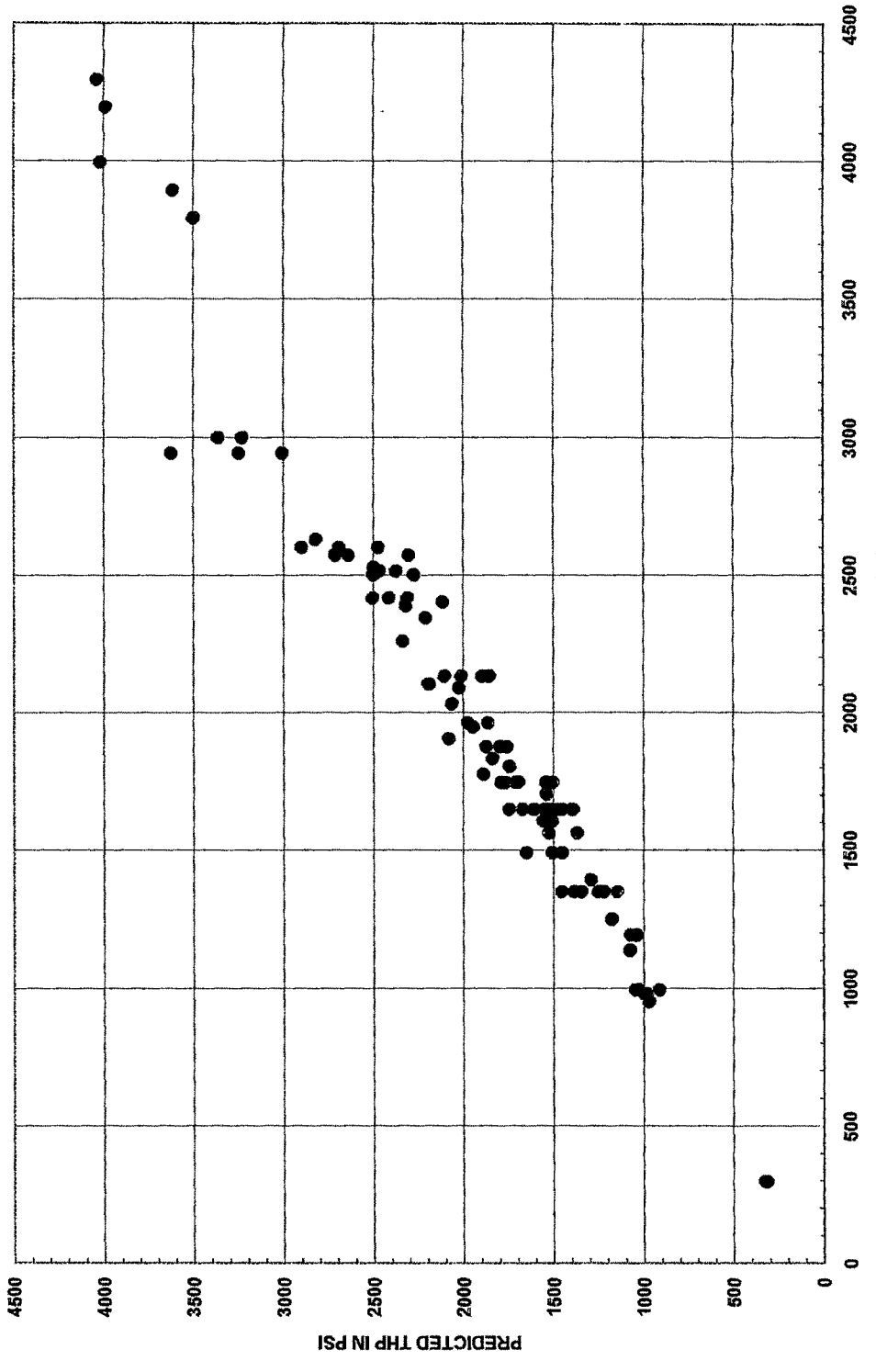


FIGURE 4.7 CROSS PLOT FOR TUBINGHEAD PRESSURE - BAXENDELL'S CORRELATION

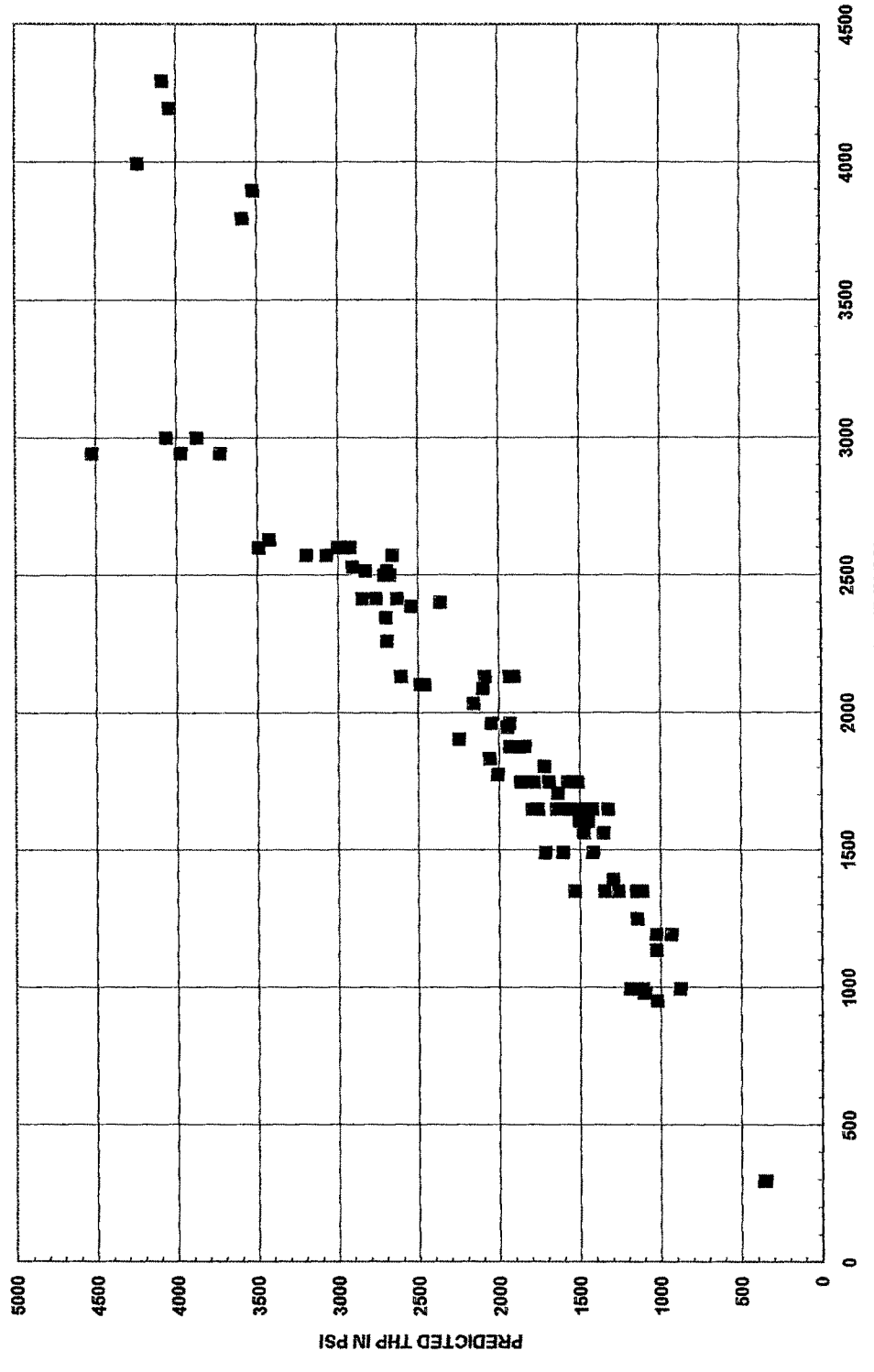


FIGURE 4.8 CROSS PLOT FOR TUBINGHEAD PRESSURE - ACHONG'S CORRELATION

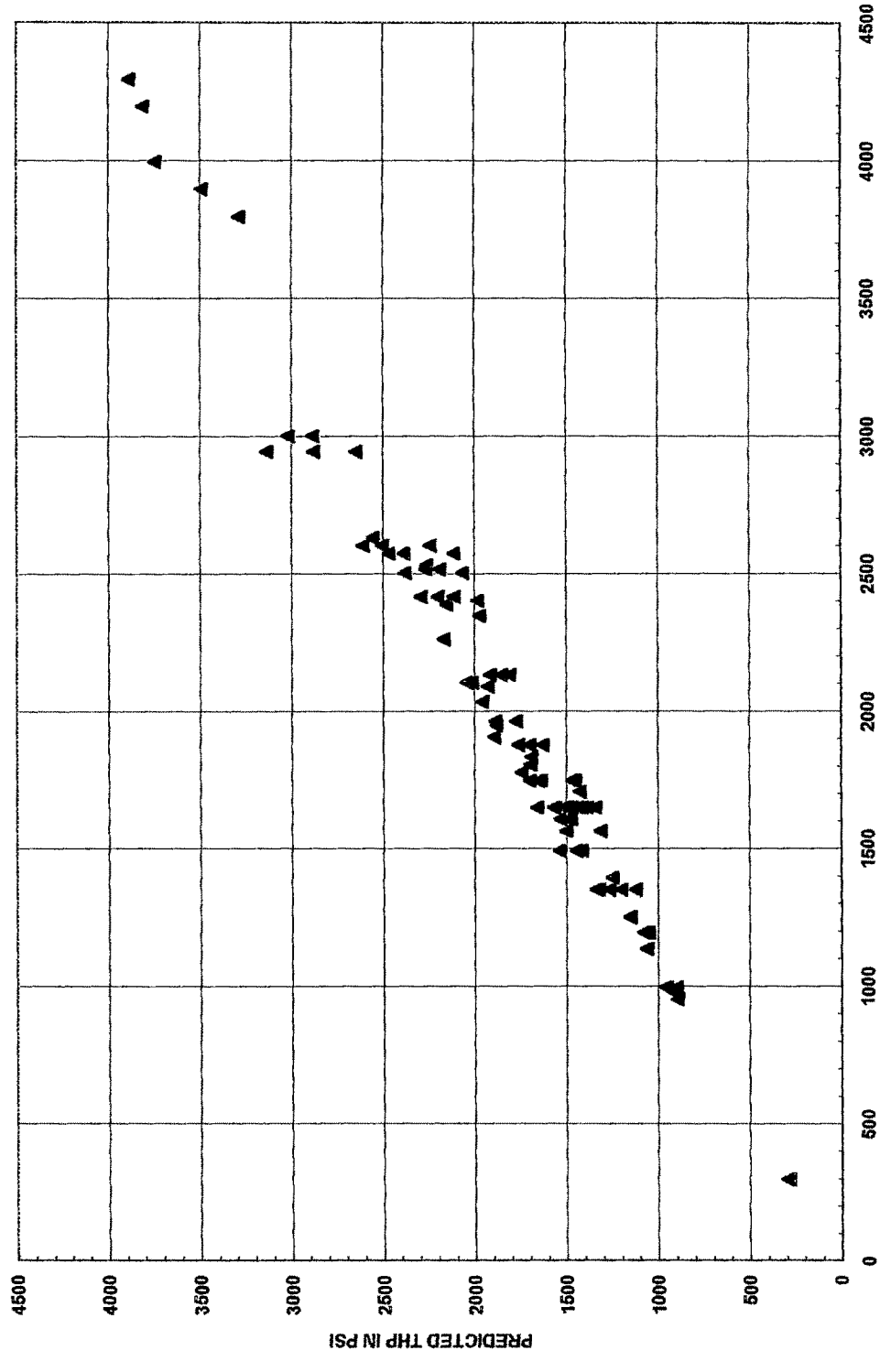


FIGURE 4.9 CROSS PLOT FOR TUBINGHEAD PRESSURE - MACH'S CORRELATION

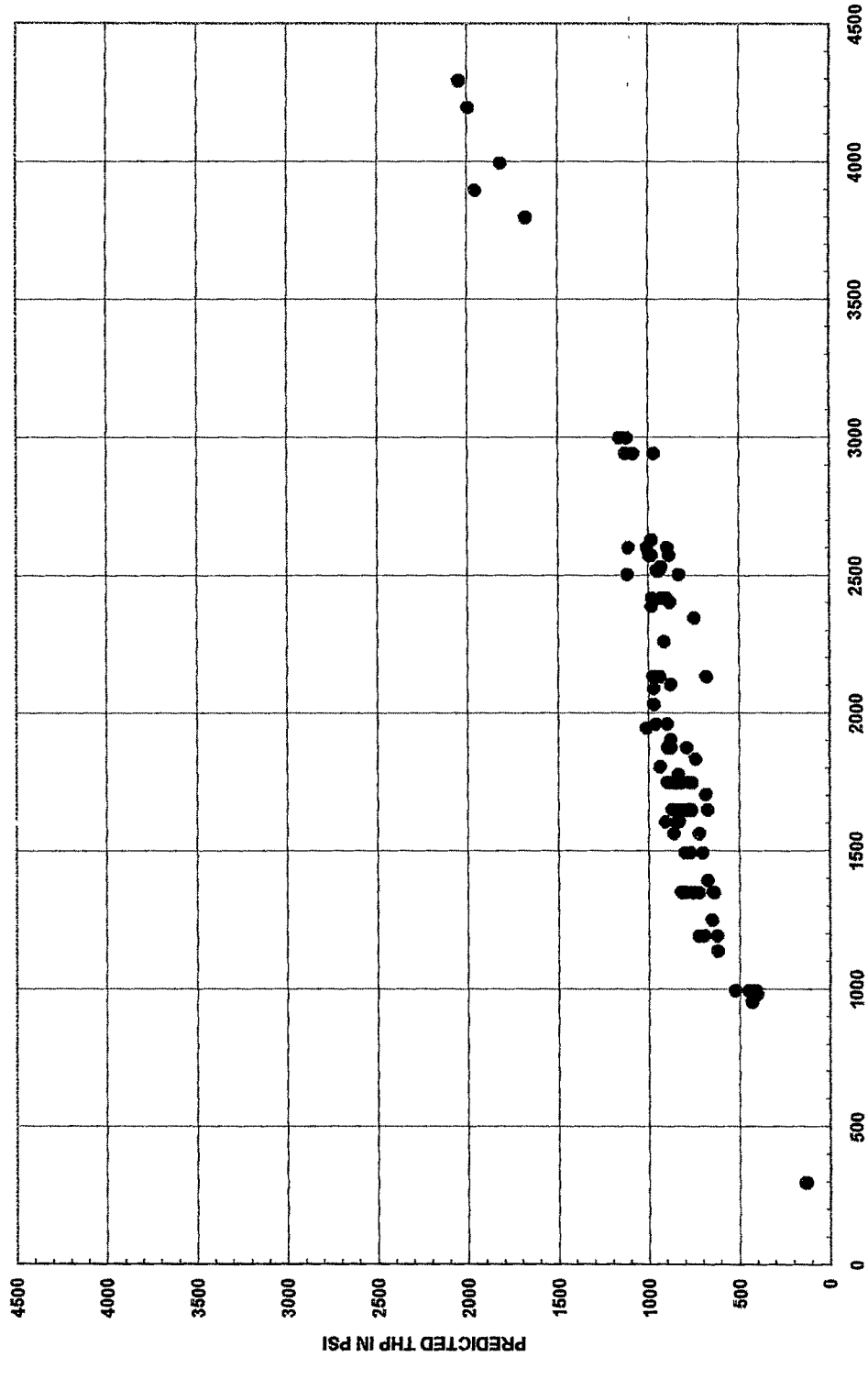


FIGURE 4.10 CROSS PLOT FOR TUBINGHEAD PRESSURE - PILEHVARI'S CORRELATION

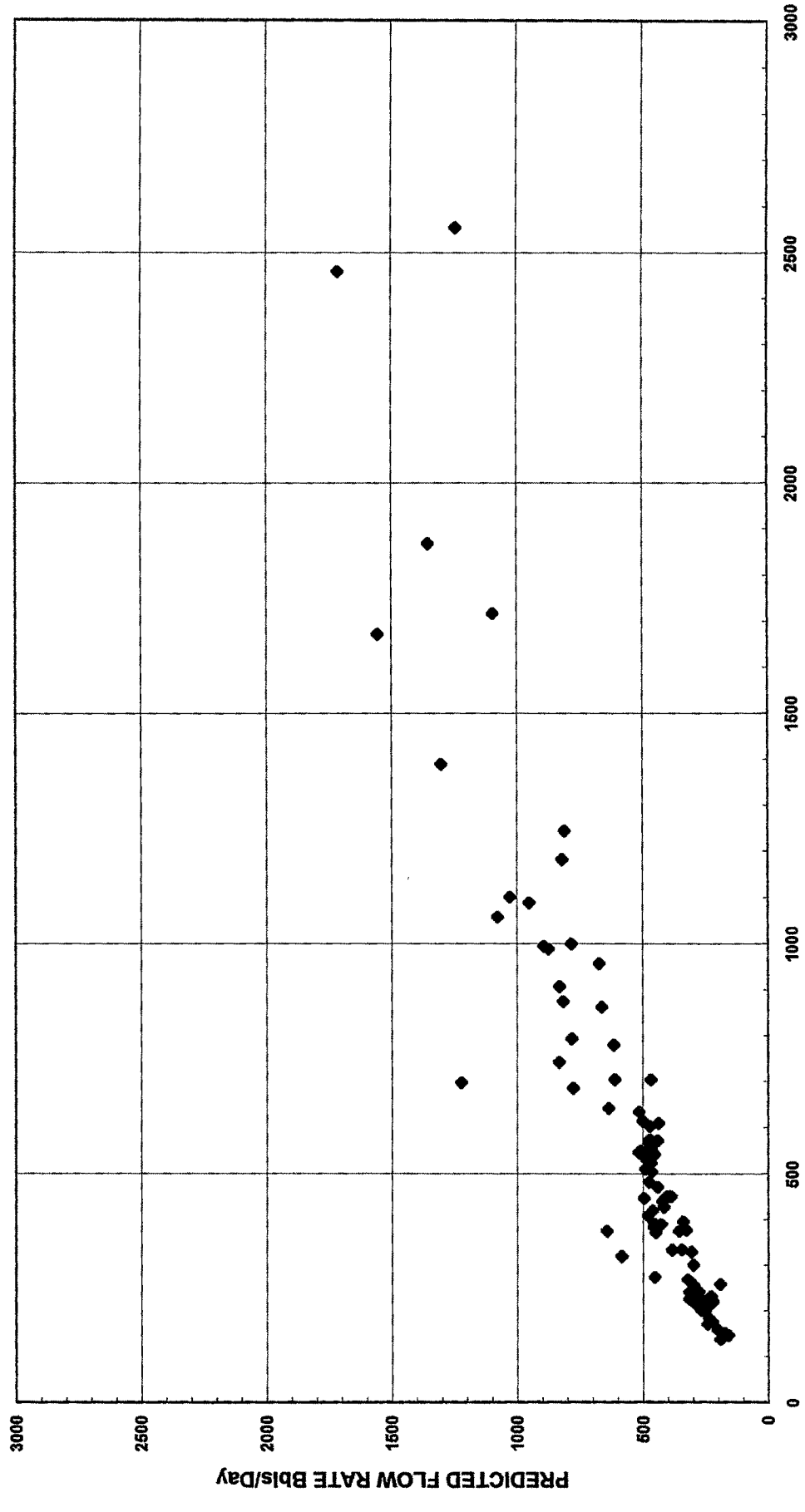


FIGURE 4.11 CROSS PLOT FOR SURFACE CHOKE FLOWRATE - PRESENT THEORETICAL MODEL

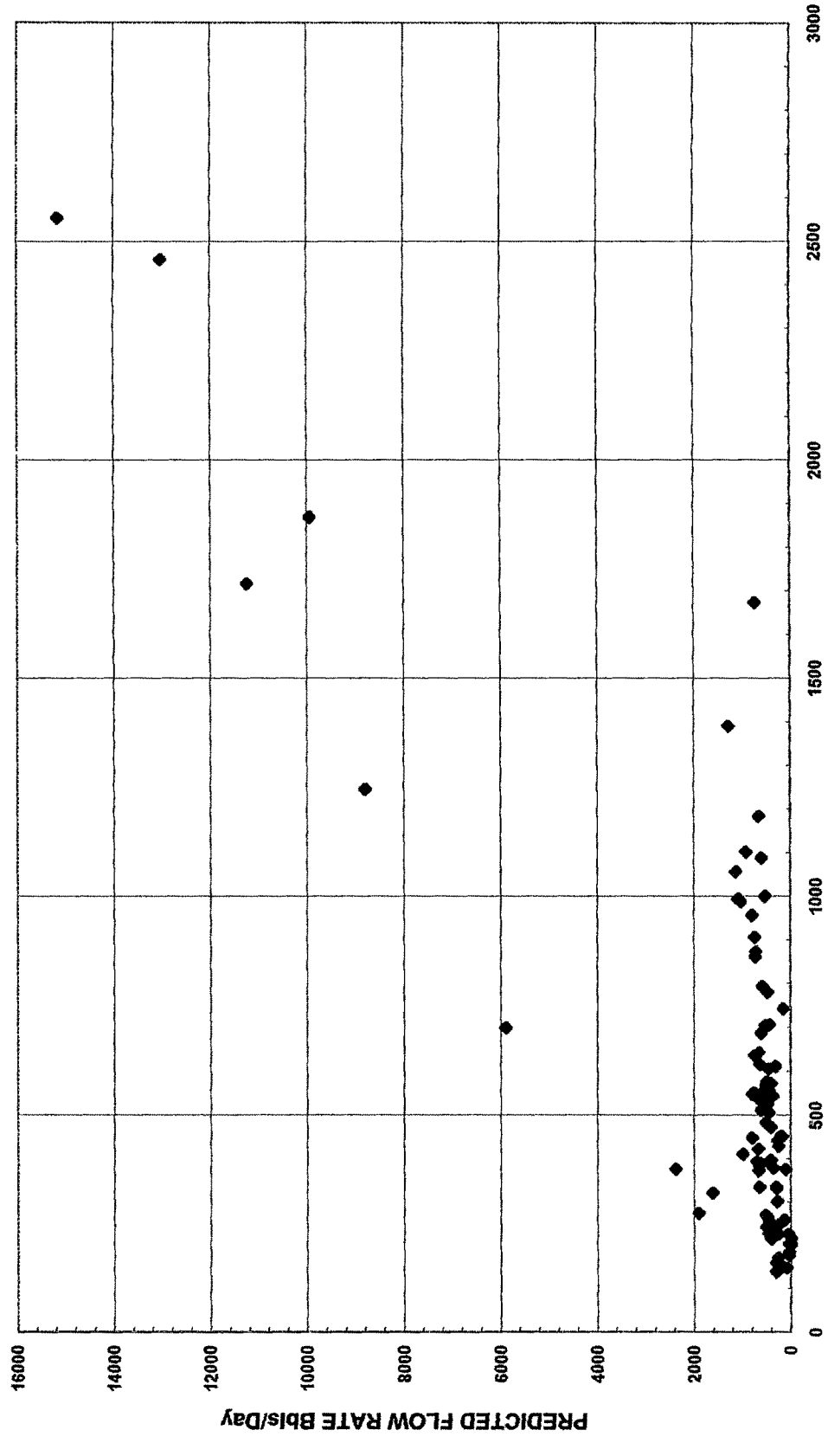


FIGURE 4.12 CROSS PLOT FOR SURFACE CHOKE FLOWRATE - OMANA'S MODEL

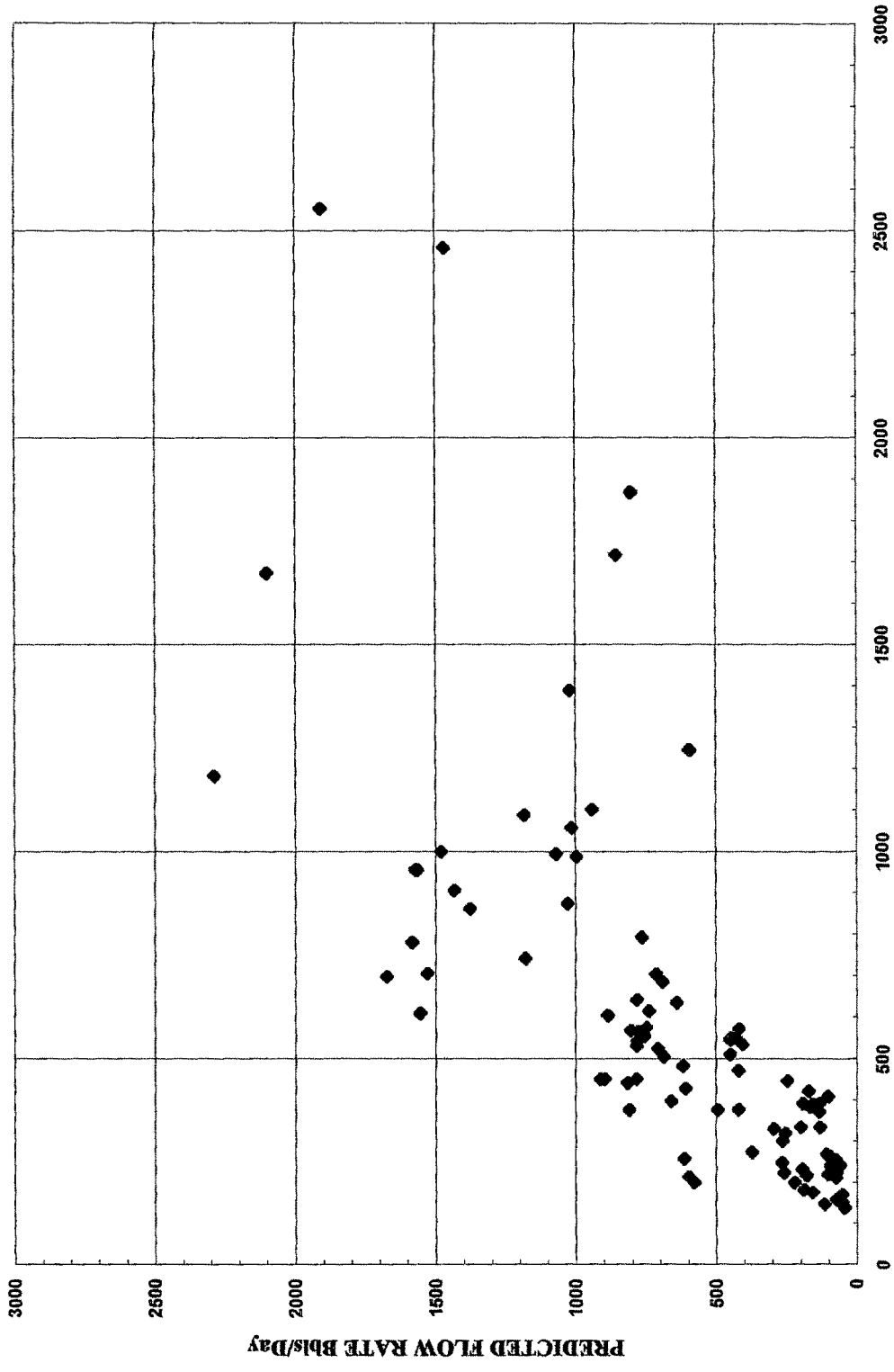


FIGURE 4.13 CROSS PLOT FOR SURFACE CHOKE FLOWRATE - POETTMANN AND BECK'S MODEL

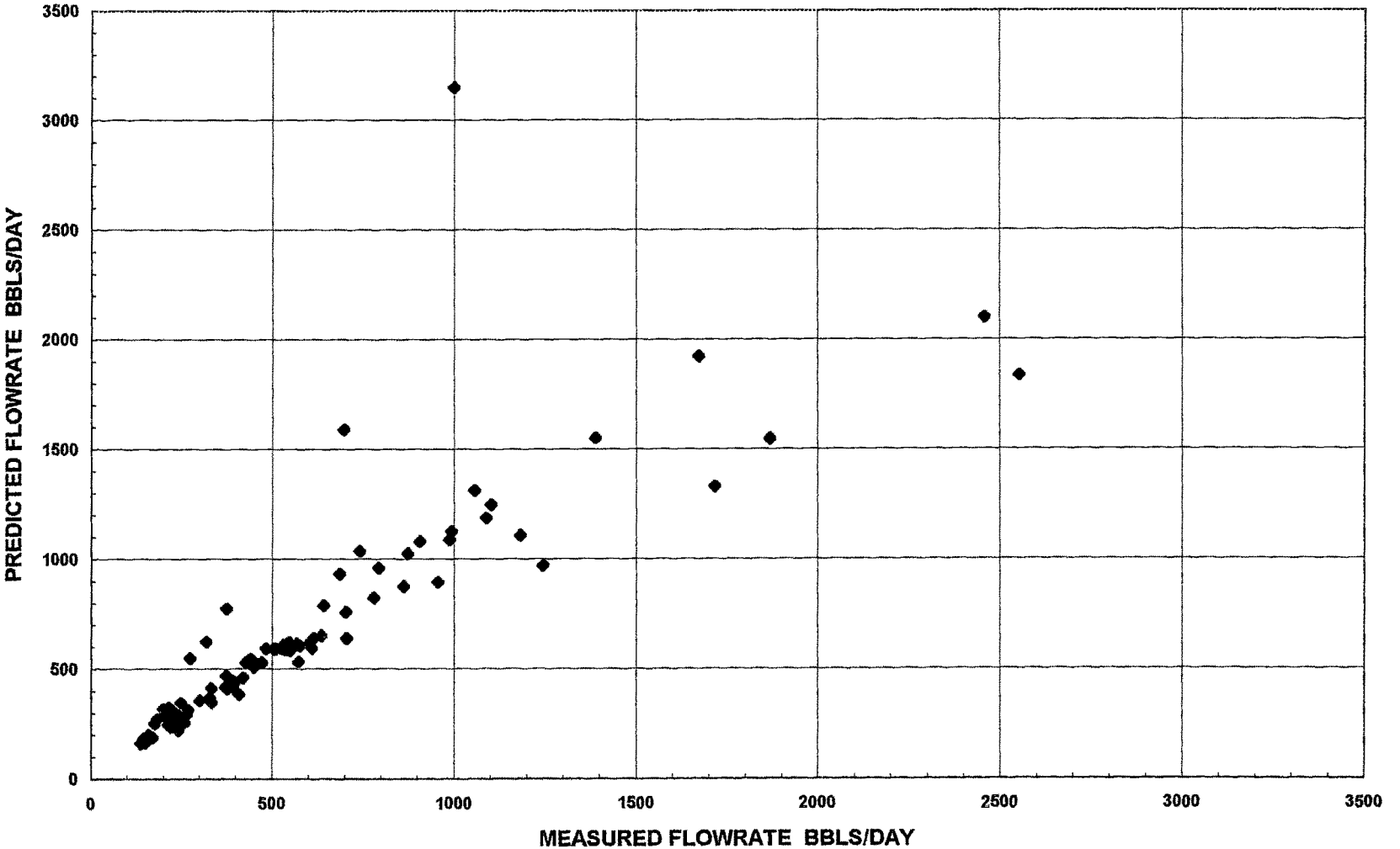


FIGURE 4.14 CROSS PLOT FOR SURFACE CHOKE FLOWRATE - ASHFORD'S MODEL

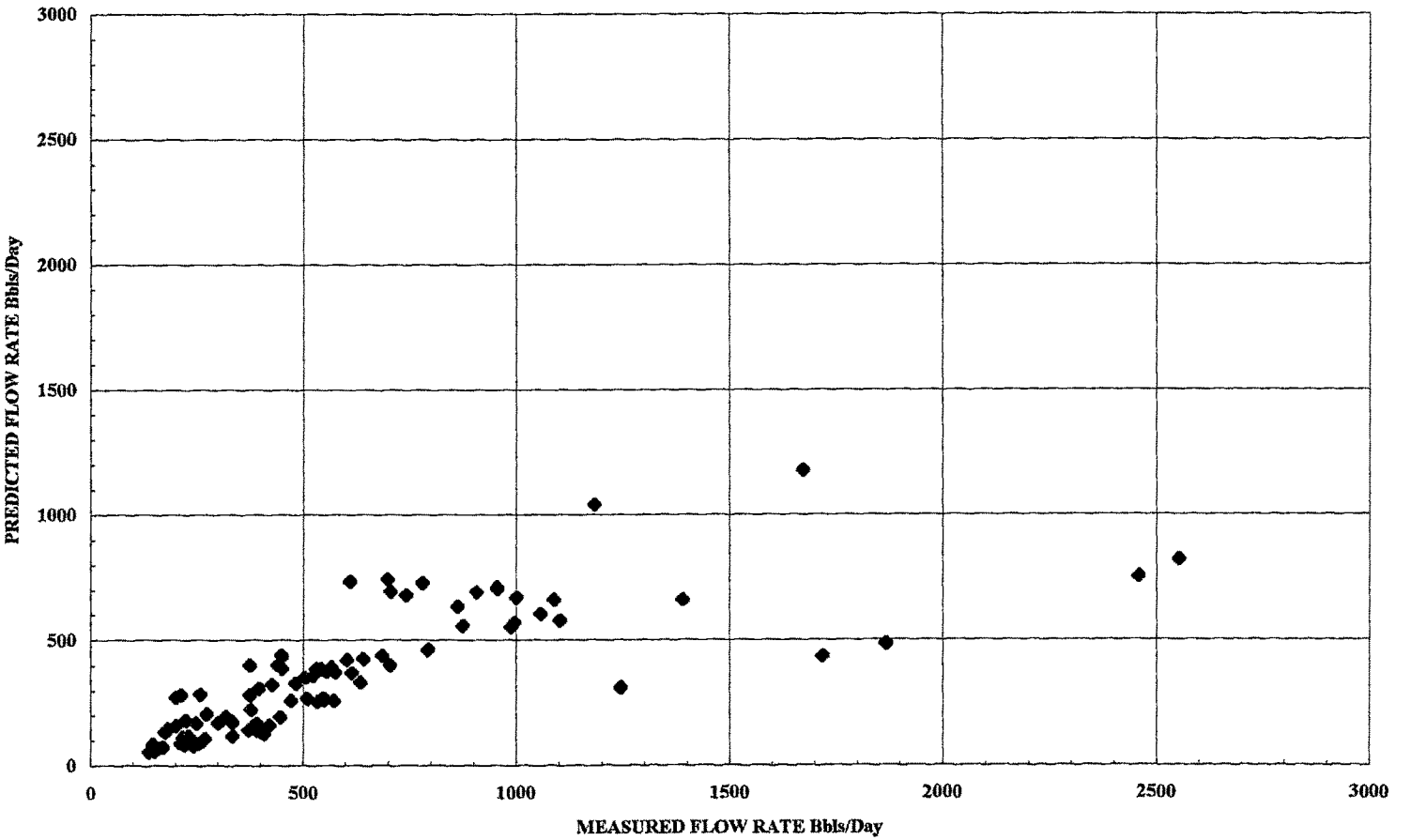


FIGURE 4.15 CROSS PLOT FOR SURFACE CHOKE FLOW RATE -SACHDEVA'S MODEL

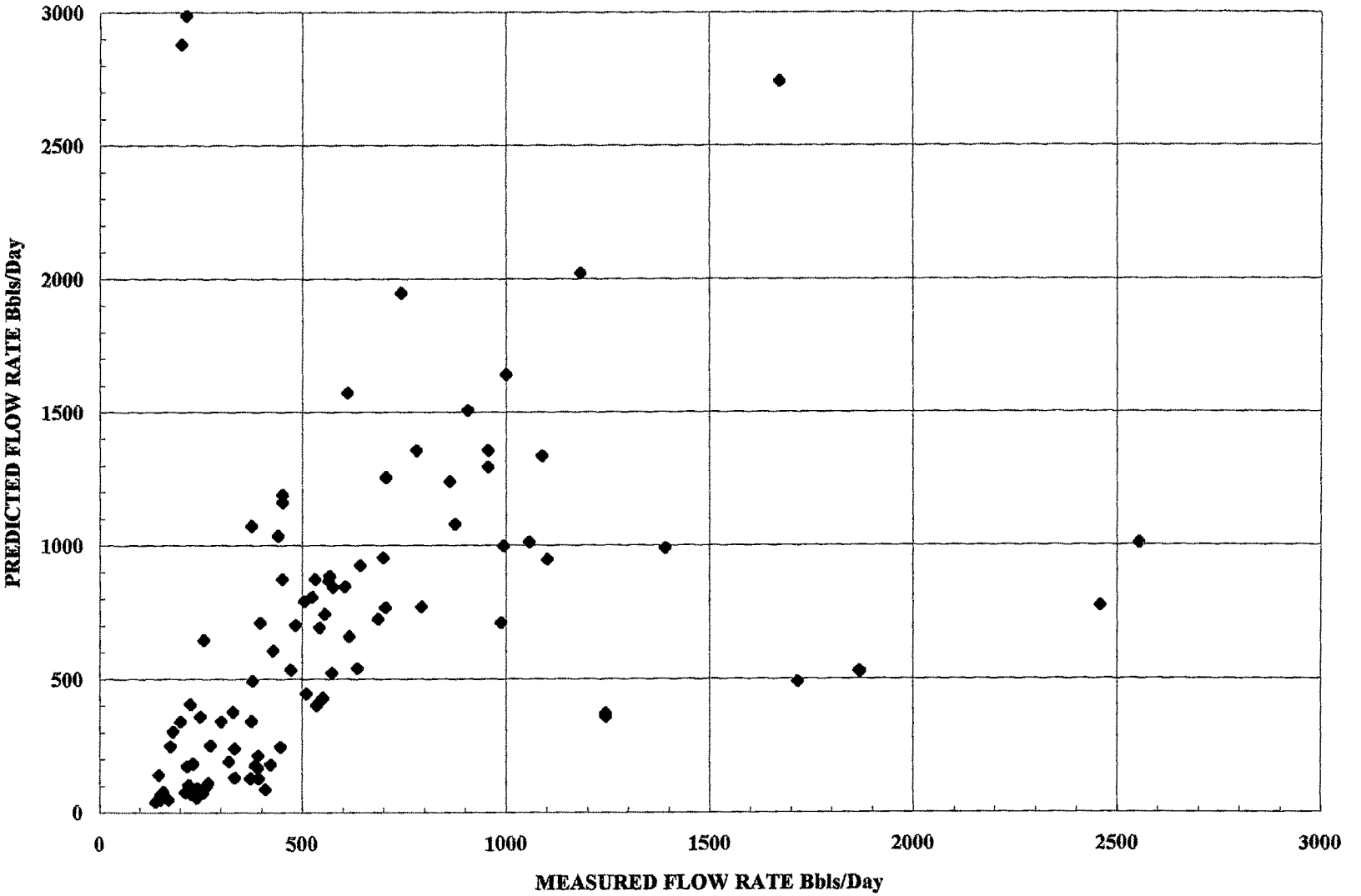


FIGURE 4.16 CROSS PLOT FOR SURFACE CHOKE FLOW RATE - PERKINS' MODEL

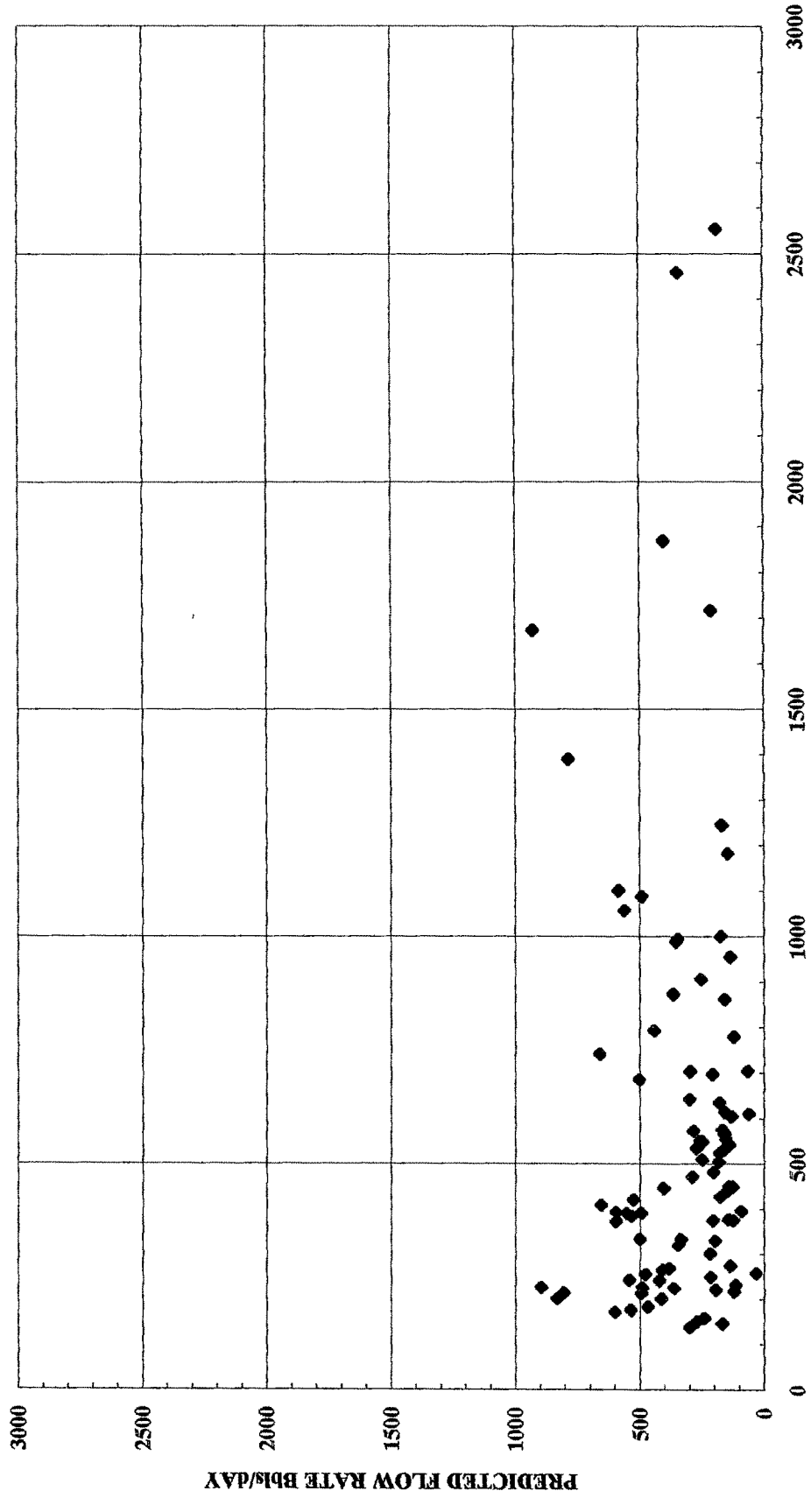


FIGURE 4.17 CROSS PLOT FOR SURFACE CHOKE FLOW RATE - ASHFORD PIERCE'S MODEL