# Modeling and Simulation Studies of a Variable Speed Compressor

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***Abstract*— With the increasing need for optimizing the power consumption and to regulate emissions from any process plant, large number of manufacturers looking towards to operating compressors using variable speed drives. The performance of a gas compressor cab be described by the relationship of Actual Flow (Q), Isentropic Head (H), Isentropic Efficiency (η), with the operating speed as a parameter (Reference 1). In this paper a computer model has been developed to simulate the variation of power, pressure with inlet flowrate of the compressor and rotation speed of the compressor. It is found that the head, power, pressure ratios can be related to inlet volumetric rate of the compressor using a quadratic expression. It is also found that this variable can be linearly fitted to the speed of the compressor. When multiple speed data curves are given a compressor performance can be predicted at an unknown speed**

***Keywords*— Variable speed compressor, Process Simulation and Modeling, Least square analysis.***

## I. Introduction

Centrifugal compressors are the preferred mean of compressing the gas in a process system. Centrifugal compressors exhibit performance characteristics that depend on the operating point imposed on them by the process (Reference 3). It is thus, necessary for a process simulation model to determine the performance of the gas compressor depending on the head and flow requirement of the operating point, and subsequently, the performance of the compressor as a function of the speed and absorbed power .With the increasing need for optimizing the power consumption and to regulate emissions from any process plant, large number of manufacturers looking towards to operating compressors using variable speed drives (Reference 4). The performance of a gas compressor is described by the relationship of Actual Flow (Q), Isentropic Head (H), Isentropic Efficiency (η), with the operating speed as a parameter. Typical manufacturer data includes a map containing this information, which looks as shown below (Refer to Fig. 1

## II. Advantages

The advantages of predicting the performance of a compressor at variable speeds are as follows

- Multiple number of compressor performance curves can be generated
- Extrapolation for speeds which fall beyond the data for which user has data
- Head vs Flow data generation , when compressor operates on a fluid with a different MWt than for which user has data
- Surge and stonewall prediction for various RPMs and MWts

## III. Procedure for performance curve fitting

When a user wants to simulate and find the compressor performance curve, itll be necessary for user to fit performance of the compressor to an equation.If the compressor performance data is Head vs flow then this data can be fitted to an equation say a polynomial of the order 2, which looks as follows.

H=a*Q^2+b*Q+c ---- (1)

From the performance data H and Q are available. A computer program can be written to find the parameters a through e . A Sum of squares of errors method can be employed to find these parameters.

(H-(a*Q^2+b*Q+c) )^2=0---- (2)

Once these parameters are available, using the same equation (1) the performance of the compressor can be estimated any unknown flow rates. And when the values estimates from the generated parameters and plotted against the data available it should exactly overlap. Same method can be employed to predicted other performances of the compressor like Outlet pressure, Outlet Temperature and work vs Flowrate

Generally compressor vendors provide the compressors performance data at 5 to 6 operating speeds, ranging from 80% to 105% of the normal operating speed (100%). So users will have data only at these operating speeds, but when user wants to predict the performance of a compressor at a speed for which data is not available following procedure need to be employed

If RPM is the Speed of the Compressor and H is the Head developed at any given flow rate. As shown in the above diagram if user has the data at 11347 and 14184 RPMs and needs to predict the performance data at a speed of 12766 RPM following linear fitting can be used to generate Head data at various flow rates and once the data is available same can be fitted to equation (1) to predict the Head at an unknown flow rates.

$$\frac{RPM_2 - RPM_1}{H_2 - H_1} = \frac{RPM_X - RPM_1}{H_X - H_1} \quad ----(3)$$

When the RPMx is in between RPM1 and RPM2, the Hx data generated using (3) data when plotted against the data user already has it should exactly fall in between as shown in Fig (2) .Above mentioned two techniques are very important in curve fitting in any commercial simulation.

## IV. Results and Discussion

### A. To model multiple performance curves

The first step in predicting the compressor performance is to be able to read the data for different speeds and be able to fit that data to equation (1). The data in table (1) is considered as input data and when the model is run following output is generated as shown in table (2) & table (3). From the figure 2 it's clear that the input data and fitted curve data match properly without much deviation. Now same fitted curve can be used to predict head value at a given volumetric rate for input speeds. The purpose of this step is to make the view the compressor performance curves in graphical format only

### B. To compare the fitted data with output from program

Now that the input data is fitted to equations, next step is to run the compressor model at the speed which is equal to input data. In this step the compressor model is run at a speed of 11347. A case study is run varying the inlet molar rate of the entering fluid and output adiabatic head is calculated (refer to table 4). The resulting adiabatic head is plot against the inlet volumetric rate. From fig. 4 it is clear that the compressor is running properly at the user supplied speed.

### C. To get the performance at unknown speed

In step 3, the compressor input speed it changed from 11347 to 12000. Same case study as mentioned in step-2 is run and the compressor output data (table 5) of Adiabatic Head vs Volumetric Rate is plot. The compress output is shown in middle curve in fig 5. It falls exactly it between the two compressor performance curves without any overlapping.

### D. To get the performance for Output Pressure curves

The procedure explained in section-1 can be extended to performance data of Outlet Pressure of the compressor vs Inlet volumetric rate. The compressor is operated at a speed of 12000 RPM which is the speed at which no performance data is available. Case study is run by varying the inlet molar rate and Outlet pressure output is generated. The data in tables 6,7 & 8 plot as Outlet pressure against Volumetric rate as shown in fig.6, The middle curve gives the output from compressor case study.

### E. To introduce the efficiency curves

All the above steps from step-1 to step -4 are at a constant efficiency of 100%. But generally the compressor efficiency curves are provided by vendors at different RPMs. The same method as mentioned in section-1 which is used to predict the performance as Head vs Volumetric rate can be used to predict the efficiency values at different volumetric rates and Speeds. The efficiency curve fitting for tabular data is as shown below in tables 9,10 and 11. The same data is plot as shown in Fig 7.

### F. To get the performance for Pressure Ratio curves

Similar to step-4, in which outlet pressure vs volumetric rate curves are generated, user can give performance curves in Pressure ratio vs Volumetric rate format also. When these curves along with multiple speed Efficiency curves are applied following results are obtained as shown in tables 12,13 &14. The same data is plot in Fig 8.

### G. Surge Points prediction

The next step is the prediction of surge point. User needs to mention for each performance curve what is the surge point; only then percentage surge can be predicted. When the inlet flow goes too low the head developed by a compressor is very high and it may lead to reverse flow. When the inlet flow goes below surge point following warning is given to the user by calculating the inlet flowrate. The operating point is shown as in Fig 9.

** WARNING ** UNIT 1, 'C1' - Volumetric flow rate is at 83.158 percent of SURGE.

### H. Stonewall Points prediction

When the flowrate to the compressor is very high the inlet pressure and outlet pressure almost becomes the same. Following warning is given to the user to that effect. The operating point is shown as in Fig 10.

** WARNING ** UNIT 1, 'C1' - Volumetric flow rate is at 102.73 percent of STONE WALL.

## V. Tables

TABLE 1 General Compressor Input data

| Input Data @ RPM1 | | Input Data @ RPM2 | |
|---|---|---|---|
| Volumetric Flowrate (m3/hr) | Adiabatic Head(m) | Volumetric Flowrate(m3/hr) | Adiabatic Head(m) |
| 4919.2798 | 12654.7 | 5838.5698 | 16032.9 |
| 5457.3999 | 12545.7 | 6264.5698 | 15996.6 |
| 5995.52 | 12364.1 | 6600.8999 | 15923.9 |
| 6354.2598 | 12146.1 | 7094.1699 | 15778.6 |
| 6668.1602 | 11964.5 | 7475.3398 | 15597 |
| 6982.0601 | 11710.2 | 7968.6099 | 15233.8 |
| 7228.7002 | 11456 | 8372.2002 | 14834.2 |
| 7542.6001 | 11056.4 | 8820.6299 | 14325.6 |
| 8013.4502 | 10402.5 | 9067.2598 | 13998.7 |
| 8372.2002 | 9821.35 | 9358.7402 | 13599.1 |
| 8618.8301 | 9349.13 | 9650.2197 | 13126.9 |
| 8820.6299 | 8876.9 | 10031.4 | 12364.1 |
| 9156.9502 | 8077.75 | 10278 | 11782.9 |
| 9291.4805 | 7714.5 | 10479.8 | 11238 |

TABLE 2: COMPARISON OF INPUT PERFORMANCE DATA AND FITTED DATA AT SPEED = 11347 RPM

| Input Data | | Fitted Data | | Fitted Data | |
|---|---|---|---|---|---|
| m3/hr | Head (M) | m3/hr | Head (M) | m3/hr | Head (M) |
| 4919.28 | 12654.7 | 4919.28 | 12654.7 | 6793.72 | 11872.1 |
| 5457.4 | 12545.7 | 5026.904 | 12638.7 | 6856.5 | 11821.2 |
| 5995.52 | 12364.1 | 5134.528 | 12619.8 | 6919.28 | 11767.3 |
| 6354.26 | 12146.1 | 5242.152 | 12598 | 6982.06 | 11710.2 |
| 6668.16 | 11964.5 | 5349.776 | 12573.3 | 7031.39 | 11663.6 |
| 6982.06 | 11710.2 | 5457.4 | 12545.7 | 7080.72 | 11614.8 |
| 7228.7 | 11456 | 5565.024 | 12523.3 | 7130.04 | 11564 |
| 7542.6 | 11056.4 | 5672.648 | 12494 | 7179.37 | 11511.1 |
| 8013.45 | 10402.5 | 5780.272 | 12457.7 | 7228.7 | 11456 |
| 8372.2 | 9821.35 | 5887.896 | 12414.4 | 7291.48 | 11378.4 |
| 8618.83 | 9349.13 | 5995.52 | 12364.1 | 7354.26 | 11299.7 |
| 8820.63 | 8876.9 | 6067.268 | 12319.6 | 7417.04 | 11219.7 |
| 9156.95 | 8077.75 | 6139.016 | 12275.6 | 7479.82 | 11138.7 |
| 9291.481 | 7714.5 | 6210.764 | 12232 | 7542.6 | 11056.4 |
| | | 6282.512 | 12188.8 | 7636.77 | 10935.5 |
| | | 6354.26 | 12146.1 | 7730.94 | 10809.7 |
| | | 6417.04 | 12115.6 | 7825.11 | 10678.9 |
| | | 6479.82 | 12082.2 | 7919.28 | 10543.2 |
| | | 6542.6 | 12045.9 | 8013.45 | 10402.5 |
| | | 6605.38 | 12006.6 | 8085.2 | 10296.3 |
| | | 6668.16 | 11964.5 | 8156.95 | 10185.1 |
| | | 6730.94 | 11919.8 | 8228.7 | 10068.9 |

TABLE3: COMPARISON OF INPUT PERFORMANCE DATA AND FITTED DATA AT SPEED = 12766 RPM

| Data comparison @ Speed = 12766 RPM | | | | | |
|---|---|---|---|---|---|
| Input Data | | Fitted Data | | Fitted Data | |
| m3/hr | Head (M) | m3/hr | Head (M) | m3/hr | Head (M) |
| 5838.57 | 16032.9 | 5838.57 | 16032.9 | 7869.96 | 15317.5 |
| 6264.57 | 15996.6 | 5923.77 | 16030.6 | 7968.61 | 15233.8 |
| 6600.9 | 15923.9 | 6008.97 | 16025.9 | 8049.33 | 15158.3 |
| 7094.17 | 15778.6 | 6094.17 | 16018.6 | 8130.05 | 15080.6 |
| 7475.34 | 15597 | 6179.37 | 16008.9 | 8210.76 | 15000.7 |
| 7968.61 | 15233.8 | 6264.57 | 15996.6 | 8291.48 | 14918.5 |
| 8372.2 | 14834.2 | 6331.84 | 15983.8 | 8372.2 | 14834.2 |
| 8820.63 | 14325.6 | 6399.1 | 15970.1 | 8461.89 | 14741.3 |
| 9067.26 | 13998.7 | 6466.37 | 15955.6 | 8551.57 | 14644 |
| 9358.74 | 13599.1 | 6533.63 | 15940.2 | 8641.26 | 14542.3 |
| 9650.22 | 13126.9 | 6600.9 | 15923.9 | 8730.94 | 14436.2 |
| 10031.4 | 12364.1 | 6699.55 | 15902.9 | 8820.63 | 14325.6 |
| 10278 | 11782.9 | 6798.21 | 15877.9 | 8869.96 | 14261 |
| 10479.8 | 11238 | 6896.86 | 15848.9 | 8919.28 | 14196.1 |
| 10883.4 | 9748.7 | 6995.52 | 15815.8 | 8968.61 | 14130.7 |
| | | 7094.17 | 15778.6 | 9017.93 | 14064.9 |
| | | 7170.4 | 15749.2 | 9067.26 | 13998.7 |
| | | 7246.64 | 15716.3 | 9125.56 | 13924.6 |
| | | 7322.87 | 15680 | 9183.85 | 13847.6 |
| | | 7399.11 | 15640.2 | 9242.15 | 13767.7 |
| | | 7475.34 | 15597 | 9300.44 | 13684.8 |
| | | 7573.99 | 15535.4 | 9358.74 | 13599.1 |
| | | 7672.65 | 15468.3 | 9417.04 | 13512.4 |
| | | 7771.3 | 15395.6 | 9475.33 | 13421.8 |

TABLE 4: COMPARISON OF FITTED DATA WITH COMPRESSOR OUTPUT DATA AT SPEED = 11347 RPM

| **Compressor output data @ Speed = 11347 RPM** | | | |
|---|---|---|---|
| m3/hr | Head, M | m3/hr | Head, M |
| 5454.3657 | 12550.812 | 7227.0347 | 11461.819 |
| 5590.7251 | 12521.252 | 7363.394 | 11291.956 |
| 5727.084 | 12480.771 | 7499.7529 | 11116.46 |
| 5863.4434 | 12429.079 | 7636.1123 | 10940.108 |
| 5999.8022 | 12365.663 | 7772.4712 | 10756.279 |
| 6136.1616 | 12281.509 | 7908.8306 | 10562.079 |
| 6272.5205 | 12198.968 | 8045.1895 | 10359.681 |
| 6408.8799 | 12123.874 | 8181.5488 | 10149.267 |
| 6545.2388 | 12048.396 | 8317.9082 | 9920.7471 |
| 6681.5981 | 11959.294 | 8454.2666 | 9680.3398 |
| 6817.957 | 11856.876 | 8590.626 | 9412.1992 |
| 6954.3164 | 11739.811 | 8726.9854 | 9099.832 |
| 7090.6758 | 11608.71 | | |

TABLE5: COMPRESSOR OUTPUT PERFORMANCE DATA AT SPEED = 12000 RPM

| Compressor output @ speed = 12000 RPM | | | | | |
|---|---|---|---|---|---|
| m3/hr | Head, M | m3/hr | Head, M | m3/hr | Head, M |
| 5454.37 | 14146.3 | 6681.598 | 13778.6 | 7772.471 | 12893 |
| 5590.73 | 14136.4 | 6817.957 | 13707.3 | 7908.831 | 12738 |
| 5727.08 | 14117.6 | 6954.316 | 13624.6 | 8045.19 | 12572 |
| 5863.44 | 14089.9 | 7090.676 | 13530.8 | 8181.549 | 12398 |
| 5999.8 | 14052.9 | 7227.035 | 13426.3 | 8317.908 | 12210 |
| 6136.16 | 14001.8 | 7363.394 | 13304.3 | 8454.267 | 12015 |
| 6272.52 | 13948.5 | 7499.753 | 13174.1 | 8590.626 | 11802 |
| 6408.88 | 13895.5 | 7636.112 | 13038.1 | 8726.985 | 11560 |
| 6545.24 | 13840.6 | | | | |

TABLE 6: COMPARISON OF INPUT PERFORMANCE DATA AND FITTED DATA AT SPEED = 11347 RPM

| Speed @ RPM = 11347 | | | | | |
|---|---|---|---|---|---|
| Input Data | | Fitted data | | | |
| m3/hr | K Pa | m3/hr | K Pa | m3/hr | K Pa |
| 5357.8 | 2276.8 | 5357.8 | 2276.8 | 6677 | 2236.8 |
| 5996.8 | 2267.7 | 5485.6 | 2276.4 | 6786 | 2229.5 |
| 6460.1 | 2249.4 | 5613.4 | 2275.3 | 6895 | 2221.5 |
| 7003.2 | 2212.9 | 5741.2 | 2273.5 | 7003 | 2212.9 |
| 7562.3 | 2158.2 | 5869 | 2270.9 | 7115 | 2204.5 |
| 7993.6 | 2094.3 | 5996.8 | 2267.7 | 7227 | 2194.8 |
| 8440.9 | 2030.4 | 6089.5 | 2265 | 7339 | 2183.9 |
| 8872.2 | 1948.3 | 6182.1 | 2261.8 | 7450 | 2171.7 |
| 9335.5 | 1847.9 | 6274.8 | 2258.2 | 7562 | 2158.2 |
| 9782.8 | 1729.3 | 6367.4 | 2254 | 7649 | 2145.2 |
| 10150 | 1619.8 | 6460.1 | 2249.4 | 7735 | 2132.4 |

TABLE 7: COMPARISON OF INPUT PERFORMANCE DATA AND FITTED DATA AT SPEED = 12766 RPM

| **Speed @ RPM = 12766** | | | | | |
|---|---|---|---|---|---|
| Input Data | | Fitted data | | | |
| m3/hr | K Pa | m3/hr | K Pa | m3/hr | K Pa |
| 5916.933 | 2514.07 | 5916.93 | 2514.07 | 7507.988 | 2450.876 |
| 6571.885 | 2495.82 | 6047.92 | 2511.21 | 7629.394 | 2441.18 |
| 7386.582 | 2459.32 | 6178.91 | 2507.96 | 7750.799 | 2430.229 |
| 7993.611 | 2404.56 | 6309.9 | 2504.31 | 7872.205 | 2418.024 |
| 8520.767 | 2331.56 | 6440.9 | 2500.26 | 7993.611 | 2404.563 |
| 9000 | 2249.43 | 6571.89 | 2495.82 | 8099.042 | 2391.415 |
| 9511.183 | 2158.18 | 6734.82 | 2491.91 | 8204.473 | 2377.541 |
| 9862.62 | 2076.05 | 6897.76 | 2486.3 | 8309.904 | 2362.94 |
| 10357.83 | 1939.16 | 7060.7 | 2479 | 8415.336 | 2347.613 |
| 10996.81 | 1701.9 | 7223.64 | 2470.01 | 8520.767 | 2331.559 |

TABLE 8: COMPRESSOR OUTPUT PERFORMANCE DATA AT SPEED = 12000 RPM

| Output data @ 12000 RPM | | | | | |
|---|---|---|---|---|---|
| m3/hr | Kpa | m3/hr | Kpa | m3/hr | Kpa |
| 5509.294 | 2388.66 | 7850.75 | 2255.6 | 10054.46 | 1823.55 |
| 5647.027 | 2387.14 | 7988.48 | 2237.76 | 10192.2 | 1782.79 |
| 5784.759 | 2384.96 | 8126.21 | 2220.41 | 10329.93 | 1739.75 |
| 5922.492 | 2382.1 | 8263.94 | 2201.45 | 10467.66 | 1694.42 |
| 6060.224 | 2378.65 | 8401.68 | 2180.81 | 10605.39 | 1646.81 |
| 6197.957 | 2374.53 | 8539.41 | 2157.95 | 10743.13 | 1596.91 |
| 6335.689 | 2369.64 | 8677.14 | 2133.28 | 10880.86 | 1544.73 |
| 6473.421 | 2363.99 | 8814.87 | 2107.88 | 11018.59 | 1490.26 |
| 6611.154 | 2357.86 | 8952.6 | 2082.16 | 11156.32 | 1433.5 |
| 6748.886 | 2351.45 | 9090.34 | 2056.59 | 11294.05 | 1374.46 |
| 6886.618 | 2343.91 | 9228.07 | 2029.51 | 11431.79 | 1313.13 |
| 7024.351 | 2335.38 | 9365.8 | 2000.13 | 11569.52 | 1249.52 |
| 7162.083 | 2326.23 | 9503.53 | 1968.39 | 11707.25 | 1183.62 |
| 7299.815 | 2315.48 | 9641.27 | 1934.53 | 11844.98 | 1115.44 |
| 7437.548 | 2303.27 | 9779 | 1898.94 | 11982.72 | 1044.97 |
| 7575.28 | 2289.42 | 9916.73 | 1862.02 | 12120.45 | 972.213 |
| 7713.013 | 2272.82 | | | 12120.45 | 897.172 |

TABLE 9: COMPARISON OF INPUT EFFICIENCY DATA AND FITTED DATA AT SPEED = 11347 RPM

| Efficiendy data @ Speed RPM = 11347 | | | | | | |
|---|---|---|---|---|---|---|
| Input Data | | Fitted Data @ RPM = 11347 | | | | |
| m3/hr | Eff % | m3/hr | Eff % | m3/hr | Eff % | m3/hr |
| 5357.8 | 84 | 5358 | 84 | 7734.8 | 86.1 | 8700 |
| 5996.8 | 86 | 5486 | 84.6 | 7821.1 | 86.1 | 8786 |
| 6460.1 | 86 | 5613 | 85.1 | 7907.3 | 86 | 8872 |
| 7003.2 | 86 | 5741 | 85.5 | 7993.6 | 86 | 8965 |
| 7562.3 | 86 | 5869 | 85.8 | 8083.1 | 85.9 | 9058 |
| 7993.6 | 86 | 5997 | 86 | 8172.5 | 85.8 | 9150 |
| 8440.9 | 86 | 6089 | 86 | 8262 | 85.7 | 9243 |
| 8872.2 | 84 | 6182 | 86 | 8351.4 | 85.6 | 9335 |
| 9335.5 | 81 | 6275 | 86 | 8440.9 | 85.5 | 9425 |
| 9782.7 | 75 | 6367 | 86 | 8527.2 | 85.3 | 9514 |
| 10150 | 71 | 6460 | 86 | 8613.4 | 85 | 9604 |

TABLE 10: COMPARISON OF INPUT EFFICIENCY DATA AND FITTED DATA AT SPEED = 12766 RPM

| Efficiency Data @ RPM = 12766 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Input Data | | Fitted Data @ RPM = 12766 | | | | | |
| m3/hr | Eff % | m3/hr | Eff % | m3/hr | Eff % | m3/hr | Eff % |
| 5916.93 | 84 | 5916.93 | 84 | 8808.3 | 86.11 | 9862.62 | 83 |
| 6571.89 | 86 | 6047.92 | 84.54 | 8904.2 | 86.07 | 9961.66 | 82.4 |
| 7386.58 | 86 | 6178.91 | 85.01 | 9000 | 86 | 10060.7 | 81.6 |
| 7993.61 | 86 | 6309.9 | 85.41 | 9102.2 | 85.8 | 10159.8 | 80.8 |
| 8520.77 | 86 | 6440.9 | 85.74 | 9204.5 | 85.6 | 10258.8 | 80 |
| 9000 | 86 | 6571.89 | 86 | 9306.7 | 85.4 | 10357.8 | 79 |
| 9511.18 | 85 | 6734.82 | 86 | 9408.9 | 85.2 | 10485.6 | 77.7 |
| 9862.62 | 83 | 6897.76 | 86 | 9511.2 | 85 | 10613.4 | 76.2 |
| 10357.8 | 79 | 7060.7 | 86 | 9581.5 | 84.66 | 10741.2 | 74.6 |
| 10996.8 | 71 | 7223.64 | 86 | 9651.8 | 84.28 | 10869 | 72.9 |
| | | 8616.61 | 86.07 | 9722 | 83.88 | 10996.8 | 71 |
| | | 8712.46 | 86.11 | 9792.3 | 83.46 | | |

TABLE 11: COMPRESSOR OUTPUT EFFICIENCY DATA AT SPEED = 12000 RPM

| **Efficiency Data @ RPM = 12000** | | | | | |
|---|---|---|---|---|---|
| m3/hr | Eff % | m3/hr | Eff % | m3/hr | Eff % |
| 5509.29 | 83.38 | 7299.8 | 86 | 8814.9 | 85.1 |
| 5647.03 | 84.03 | 7437.5 | 86 | 8952.6 | 84.8 |
| 5784.76 | 84.57 | 7575.3 | 86 | 9090.3 | 84.4 |
| 5922.49 | 85.03 | 7713 | 86.03 | 9228.1 | 83.8 |
| 6060.22 | 85.35 | 7850.7 | 86.03 | 9365.8 | 82.8 |
| 6197.96 | 85.58 | 7988.5 | 86 | 9503.5 | 81.6 |
| 6335.69 | 85.76 | 8126.2 | 85.98 | 9641.3 | 80.3 |
| 6473.42 | 85.91 | 8263.9 | 85.91 | 9779 | 79 |
| 6611.15 | 86 | 8401.7 | 85.78 | 9916.7 | 77.7 |
| 6748.89 | 86 | 8539.4 | 85.61 | 10054 | 76.4 |
| 6886.62 | 86 | 8677.1 | 85.42 | 10192 | 75.2 |

TABLE 12: COMPARISON OF INPUT PRESSURE RATIO DATA AND FITTED DATA AT SPEED = 11347 RPM

| **Speed @ RPM = 11347** | | | | | |
|---|---|---|---|---|---|
| Input Data | | Fitted Data @ RPM = 11347.000000 | | | |
| m3/hr | Pres Ratio | m3/hr | Pres Ratio | m3/hr | Pres Ratio |
| 5357.8 | 2.46 | 5357.8 | 2.465 | 6568.69 | 2.428365 |
| 5996.8 | 2.45 | 5485.6 | 2.46454 | 6677.316 | 2.421047 |
| 6460.1 | 2.43 | 5613.4 | 2.46333 | 6785.942 | 2.413048 |
| 7003.2 | 2.4 | 5741.2 | 2.46135 | 6894.569 | 2.404365 |
| 7562.3 | 2.34 | 5869 | 2.45858 | 7003.195 | 2.395 |
| 7993.6 | 2.27 | 5996.8 | 2.455 | 7115.016 | 2.38595 |
| 8440.9 | 2.2 | 6089.5 | 2.45204 | 7226.837 | 2.375525 |
| 8872.2 | 2.11 | 6182.1 | 2.44856 | 7338.658 | 2.363725 |
| 9335.5 | 2 | 6274.8 | 2.44456 | 7450.48 | 2.35055 |
| 9782.7 | 1.87 | 6367.4 | 2.44004 | 7562.301 | 2.336 |
| 10150 | 1.75 | 6460.1 | 2.435 | 7648.563 | 2.322007 |

TABLE 13: COMPARISON OF INPUT PRESSURE RATIO DATA AND FITTED DATA AT SPEED = 12766 RPM

| Speed @ RPM = 12766 | | | | | |
|---|---|---|---|---|---|
| Input Data | | Fitted Data @ RPM = 12766 | | | |
| m3/hr | Pres Ratio | m3/hr | Pres Ratio | m3/hr | Pres Ratio |
| 5916.93 | 2.721 | 5916.93 | 2.721 | 7507.99 | 2.6529 |
| 6571.89 | 2.702 | 6047.92 | 2.71814 | 7629.39 | 2.6425 |
| 7386.58 | 2.662 | 6178.91 | 2.71481 | 7750.8 | 2.6307 |
| 7993.61 | 2.603 | 6309.9 | 2.71101 | 7872.21 | 2.6175 |
| 8520.77 | 2.524 | 6440.9 | 2.70674 | 7993.61 | 2.603 |
| 9000 | 2.435 | 6571.89 | 2.702 | 8099.04 | 2.5888 |
| 9511.18 | 2.336 | 6734.82 | 2.69759 | 8204.47 | 2.5738 |
| 9862.62 | 2.247 | 6897.76 | 2.69139 | 8309.9 | 2.558 |
| 10357.8 | 2.099 | 7060.7 | 2.68339 | 8415.34 | 2.5414 |
| 10996.8 | 1.842 | 7223.64 | 2.67359 | 8520.77 | 2.524 |
| | | 7386.58 | 2.662 | 8616.61 | 2.5065 |

TABLE 14: COMPRESSOR OUTPUT PERFORMANCE DATA SPEED = 12000 RPM

| Compressor output Speed 12000 RPM | | | | | |
|---|---|---|---|---|---|
| m3/hr | Pres Ratio | m3/hr | Pres Ratio | m3/hr | Pres Ratio |
| 5509.294 | 2.58524 | 6886.62 | 2.537 | 8126.21 | 2.403628 |
| 5647.027 | 2.58376 | 7024.35 | 2.5277 | 8263.942 | 2.383136 |
| 5784.759 | 2.58153 | 7162.08 | 2.5178 | 8401.675 | 2.360808 |
| 5922.492 | 2.57855 | 7299.82 | 2.5062 | 8539.406 | 2.336058 |
| 6060.224 | 2.57489 | 7437.55 | 2.4931 | 8677.139 | 2.309332 |
| 6197.957 | 2.57049 | 7575.28 | 2.4781 | 8814.871 | 2.281803 |
| 6335.689 | 2.56523 | 7713.01 | 2.4602 | 8952.604 | 2.253863 |
| 6473.421 | 2.55911 | 7850.75 | 2.4416 | 9090.336 | 2.226085 |
| 6611.154 | 2.55237 | 7988.48 | 2.4224 | 9228.068 | 2.196699 |
| 6748.886 | 2.54529 | | | 9365.801 | 2.164898 |

## VI. FIGURES

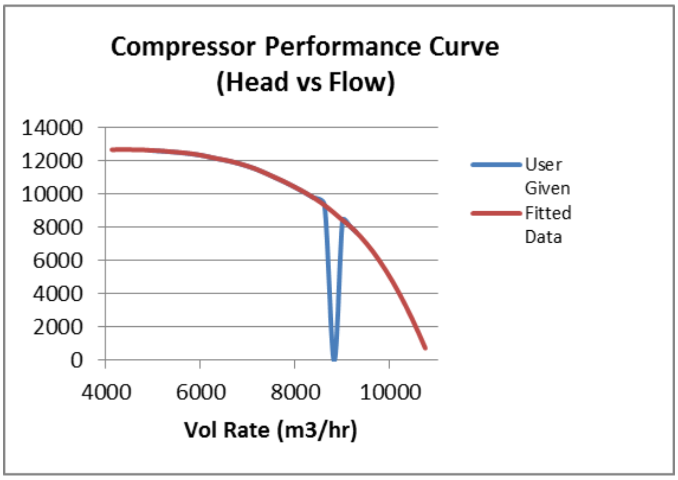


Fig 1.Compressor Performance data fitting using SSE

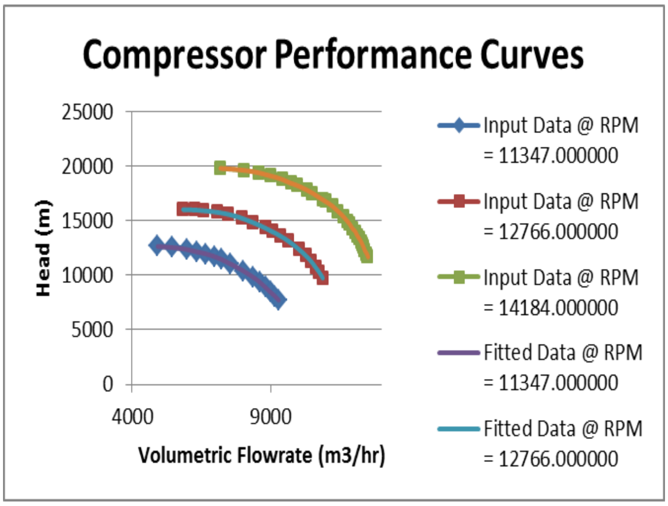


Fig 2.compressor performance

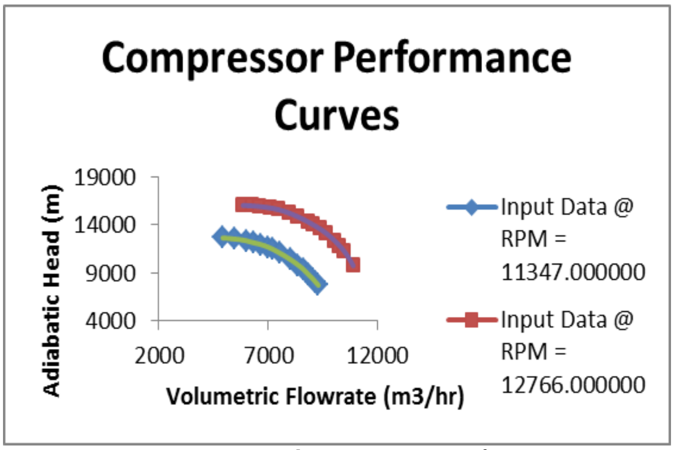


Fig 3.Compressor data viewing in curve format

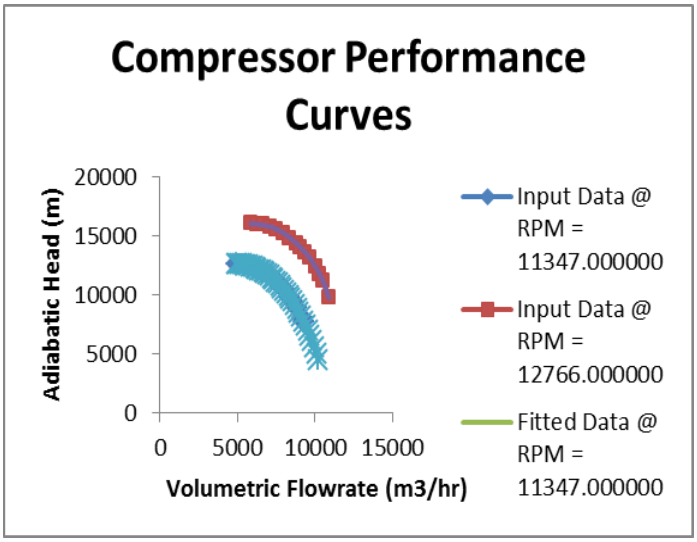


Fig 4.Compressor performance matching with the data in curve format

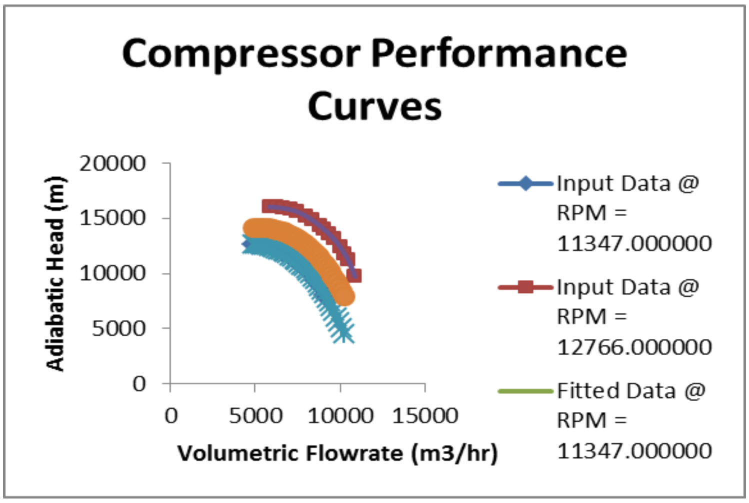


Fig 5.Compressor performance prediction at 12000 rpm

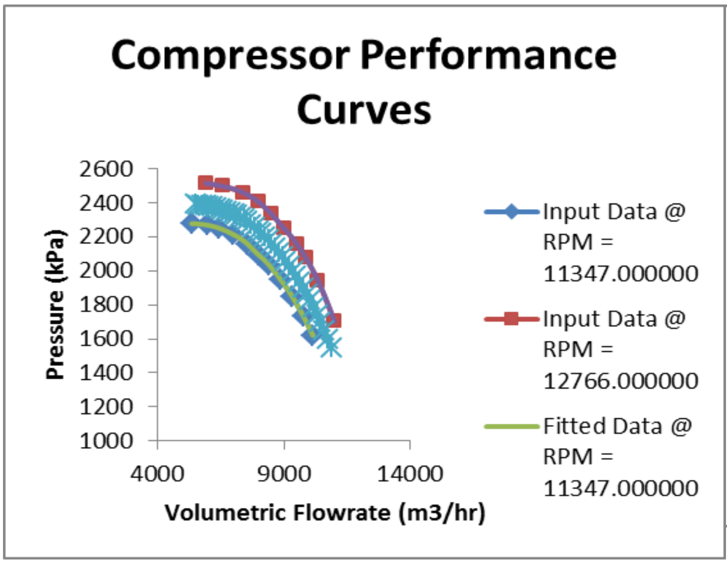


Fig 6.Compressor performance prediction at 12000 rpm

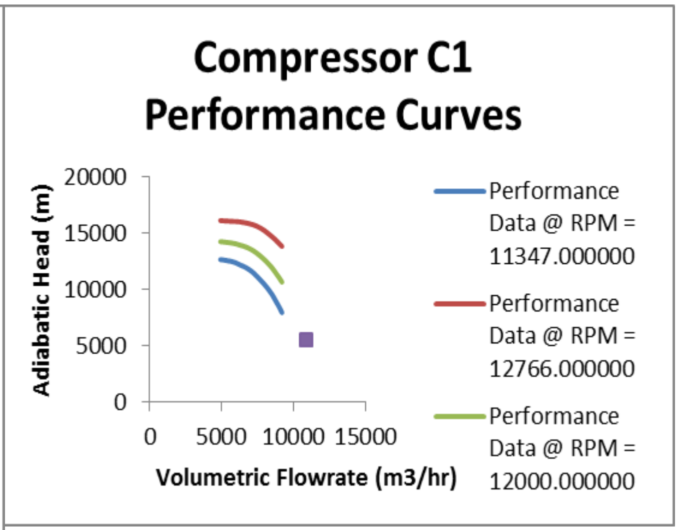


Fig 10 .Compressor stonewall point prediction at 12000 rpm

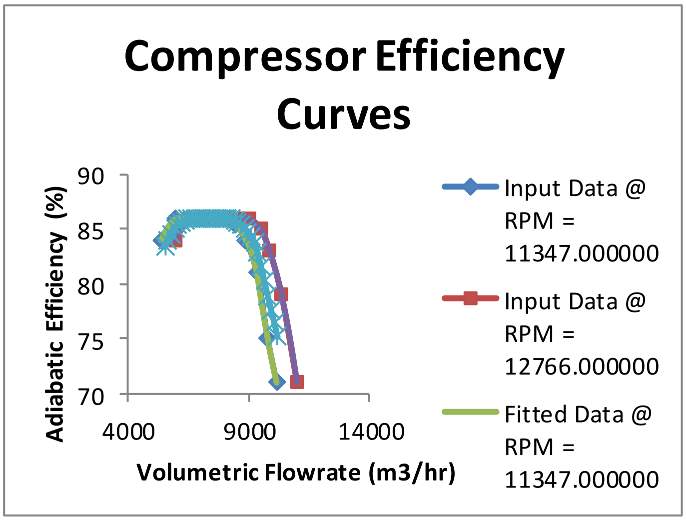


FIG 7.Compressor efficiency prediction at 12000 rpm

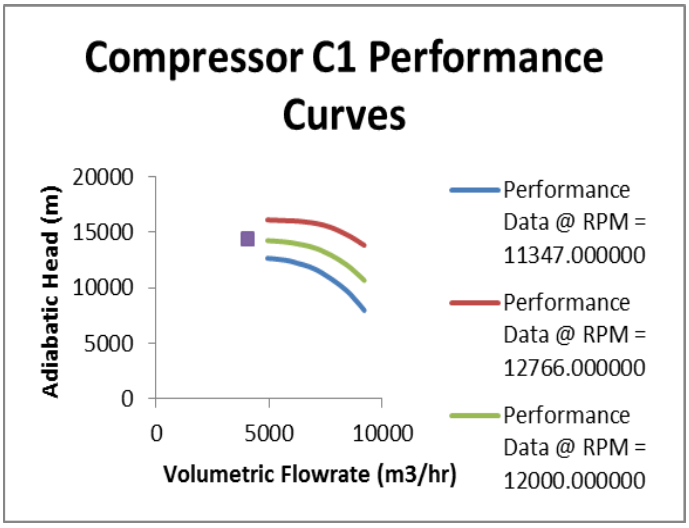


Fig 9 .Compressor surge point prediction at 12000 rpm

## VII. CONCLUSIONS

From the above analysis it’s clear that a quadratic fit will be sufficient to model performance curves of a variable speed compressor

The assumption of variation of heat developed by a compressor is linearly proportional to it’s speed can be verified

## VIII. REFERENCES

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