# Compressor Polytropic Head Calculations from Vendor Data

## [ to be used in UNISIM, HYSYS ]

Vendor Data refer to Graph-B

$$Comp_{flow} := \begin{bmatrix} 1160 \\ 1150 \\ 1120 \\ 1100 \\ 1080 \\ 1075 \end{bmatrix} \frac{m^3}{hr} \qquad Comp_{power} := \begin{bmatrix} 24 \\ 27.5 \\ 33 \\ 37 \\ 41 \\ 43 \end{bmatrix} kW$$

Absolute pressure

$$Comp_{disPress} := \begin{bmatrix} 1.1 \\ 1.2 \\ 1.350 \\ 1.450 \\ 1.6 \\ 1.7 \end{bmatrix} bar$$

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http://www.coolprop.org/fluid_properties/HumidAir.html#sample-hapropssi-code

$$\rho_{Air_20C_Saturated} := \frac{1}{CoolProp_HAProps("Vha", "P", 1\ atm, "T", 20\ °C, "R", 1)} = 1.1941 \frac{kg}{m^3}$$

For density of H2 saturated with H2O at 40C & 1.14bar [operational conditions]

$$Species := \begin{bmatrix} "Hydrogen" \\ "Water" \end{bmatrix}$$

see Graph-A

$$M_{frac} := \begin{bmatrix} 1 - 0.65 \\ 0.65 \end{bmatrix}$$

$$T := 40\ °C \qquad P := 1.14\ bar$$

$$\rho_{H2} := CoolProp_Props("D", "T", T, "P", P, Species_1) = 0.0882 \frac{kg}{m^3}$$

water vapour density

$$\rho_{satH2O} := CoolProp_Props("D", "Q", 1, "T", T, Species_2) = 0.0512 \frac{kg}{m^3}$$

$$P_{satH2O} := CoolProp_Props("P", "Q", 1, "T", T, Species_2) = 0.0738\ bar$$

One can compare result with [313K, 1.13ATM]:
https://www.engineering-4e.com/h2o-physical-properties-calculator

$$\rho_{H2O} := \rho_{satH2O} \cdot \frac{P}{P_{satH2O}} = 0.791 \frac{kg}{m^3}$$

Using mixing density formula

$$\rho_{Mix_H2_H2O} := \frac{1}{\frac{M_{frac_1}}{\rho_{H2}} + \frac{M_{frac_2}}{\rho_{H2O}}} = 0.2088 \frac{kg}{m^3}$$

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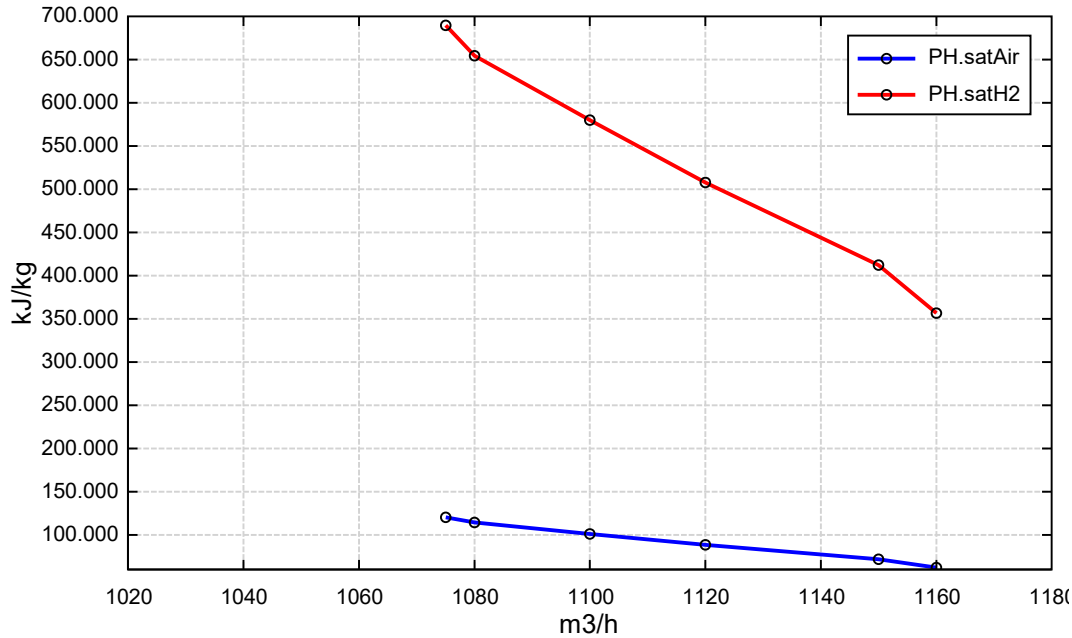
$$
\begin{aligned}
Table :=\ & MassFlow_{Air} := Comp_{flow} \cdot \rho_{Air_20C_Saturated} \\
& MassFlow_{satH2} := Comp_{flow} \cdot \rho_{Mix_H2_H2O} \\
& PH_{Air} := \frac{\overrightarrow{Comp_{power}}}{MassFlow_{Air}} \\
& PH_{satH2} := \frac{\overrightarrow{Comp_{power}}}{MassFlow_{satH2}} \\
& PH_{Air_m} := PH_{Air} \cdot \frac{1}{9.8\ \frac{N}{kg}} \\
& PH_{satH2_m} := PH_{satH2} \cdot \frac{1}{9.8\ \frac{N}{kg}} \\
& M_1 := \text{augment}\left(Comp_{flow}, MassFlow_{Air}, MassFlow_{satH2}, PH_{Air}, PH_{satH2}, PH_{Air_m}, PH_{satH2_m}, Comp_{power}\right) \\
& M_2 := \left[\frac{1}{\frac{m^3}{hr}}\ \frac{1}{\frac{kg}{hr}}\ \frac{1}{\frac{kg}{hr}}\ \frac{1}{\frac{kJ}{kg}}\ \frac{1}{\frac{kJ}{kg}}\ \frac{1}{m}\ \frac{1}{m}\ \frac{1}{kW}\right] \\
& M_3 := M_1 \cdot \text{diag}\left(M_2^{\,T}\right) \\
& M_4 := \text{augment}\left(\text{"m3/h"}, \text{"satAir kg/hr"}, \text{"satH2 kg/hr"}, \text{"PH.Air kJ/kg"}, \text{"PH.H2 kJ/kg"}, \text{"PH.Air m"}, \text{"PH.H2 m"}, \text{"kW"}\right) \\
& M_5 := \text{stack}\left(M_4, \overrightarrow{\text{round}\left(M_3, 2\right)}\right)
\end{aligned}
$$

PH refers to Polytropic Head. This can readily be used in UNISIM, HYSYS

$Table =$

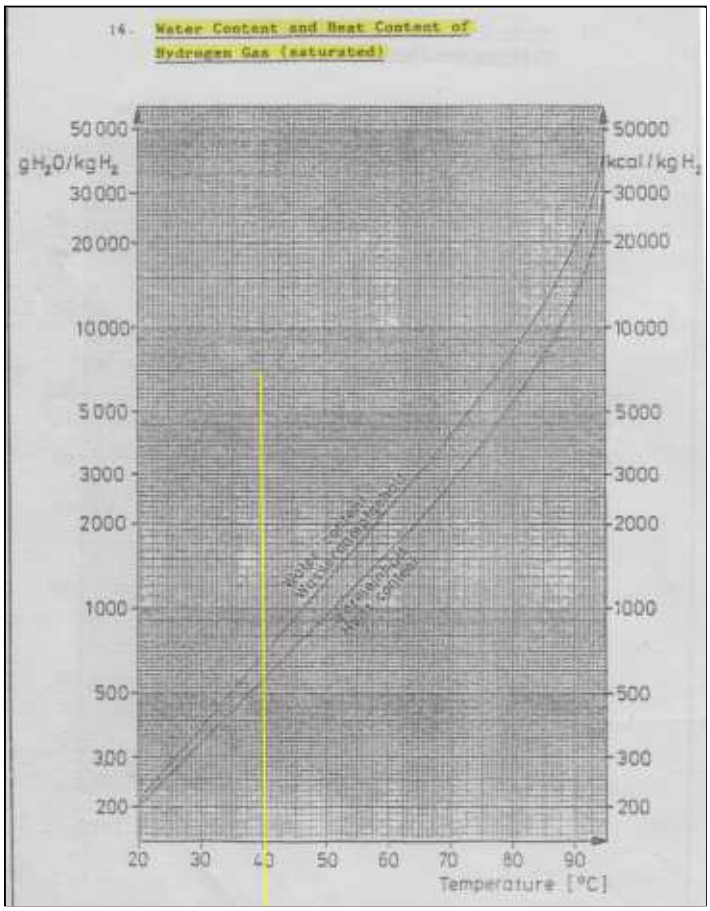
| "m3/h" | "satAir kg/hr" | "satH2 kg/hr" | "PH.Air kJ/kg" | "PH.H2 kJ/kg" | "PH.Air m" | "PH.H2 m" | "kW" |
|---|---|---|---|---|---|---|---|
| 1160 | 1385.19 | 242.19 | 62.37 | 356.75 | 6364.69 | 36402.97 | 24 |
| 1150 | 1373.25 | 240.1 | 72.09 | 412.33 | 7356.29 | 42074.44 | 27.5 |
| 1120 | 1337.43 | 233.84 | 88.83 | 508.05 | 9064 | 51841.73 | 33 |
| 1100 | 1313.55 | 229.66 | 101.4 | 579.99 | 10347.44 | 59182.4 | 37 |
| 1080 | 1289.66 | 225.48 | 114.45 | 654.59 | 11678.41 | 66794.95 | 41 |
| 1075 | 1283.69 | 224.44 | 120.59 | 689.71 | 12305.06 | 70379.07 | 43 |

See the Z-compressibility chart. H2 compression for same pressure ratio is far more energy intensive than air

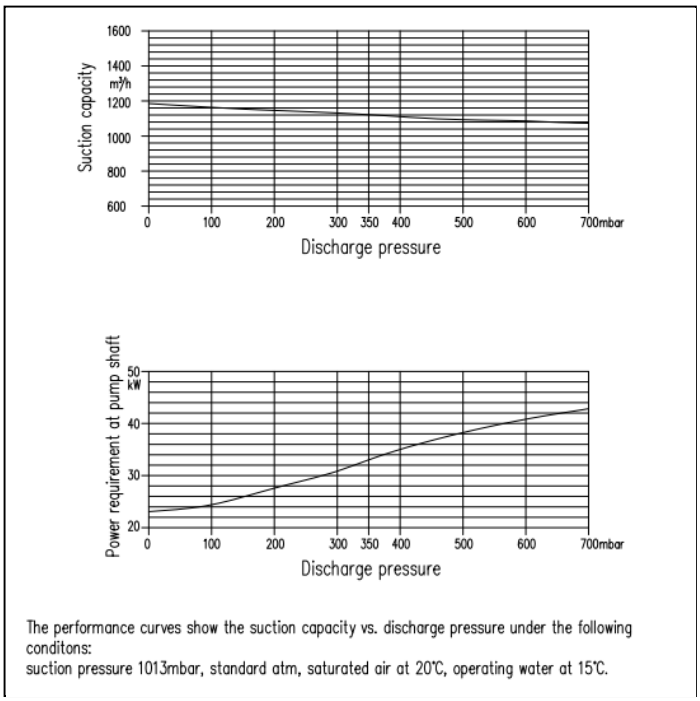


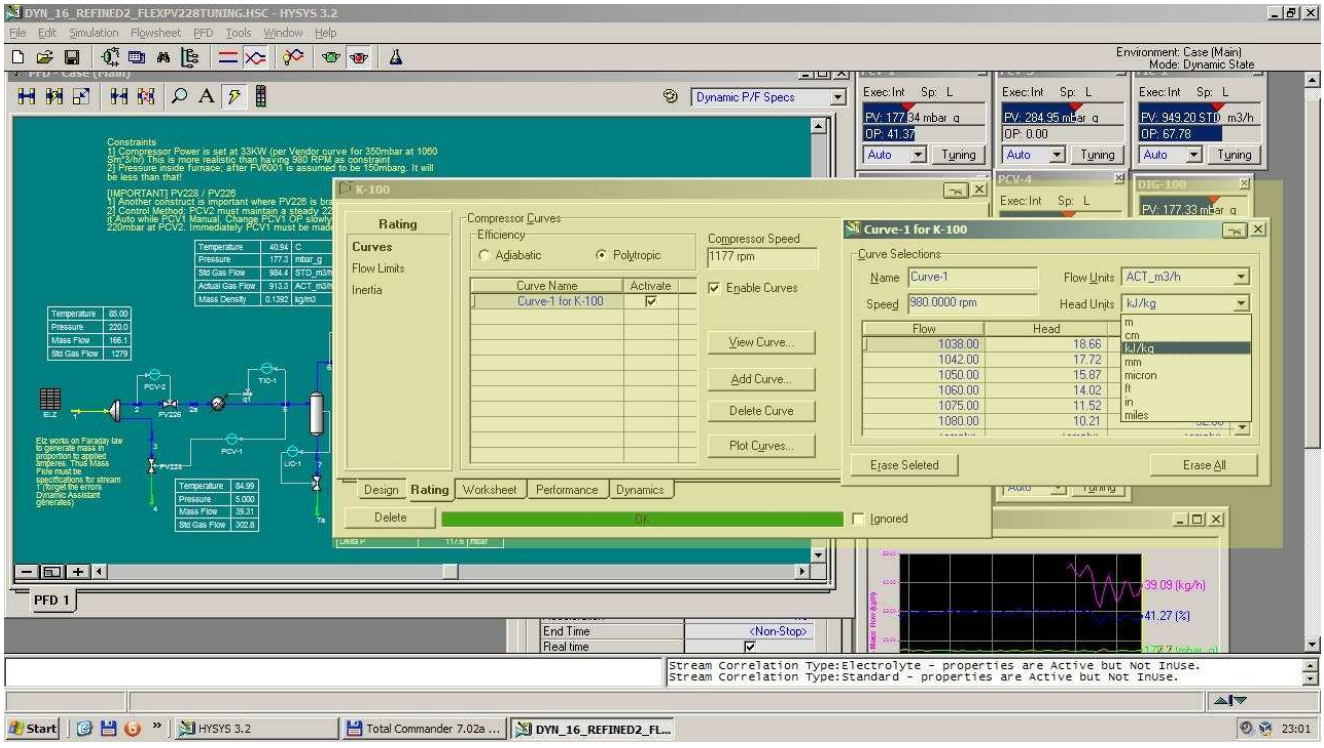

$$
\begin{cases}
\text{augment}\left(Table_{[2..7]1}, Table_{[2..7]4}\right) \\
\text{augment}\left(Table_{[2..7]1}, Table_{[2..7]5}\right)
\end{cases}
$$

**Graph - A**




**Graph - B**




**HYSYS compressor curve input option**