Analysis of end of expansion and exhaust temperatures:

Inlet temperature at $T := 850$
with an expansion ratio: $X := 5$
Analyzed over a pressure range of $p_l := 400$ PSIA to $p_h := 4500$ PSIA

Setup steam calculations to produce first 7 properties: $\text{ST\_limit}(7) = 7$
0 pressure, 1 temperature, 2 specific volume, 3 specific internal energy, 4specific enthalpy, 5 specific entropy, 6 quality.

$\boldsymbol{J} \equiv 778.169262266$ conversion factor ft lb (work) per BTU

Set up number of points to analyze and generate an array of pressure values.

$N := 32$ Number of points analyzed

$i := 0 .. N - 1$ Mathcad array index 0 to N-1

$P_i := p_l + \dfrac{p_h - p_l}{N - 1} \cdot i$ Generates an N element array of pressure values

Generate an array of steam inlet steam states.

$P1_i := \text{ST\_ptdata}(P_i, T, 1, 1)$ initial inlet steam state

First and last inlet steam state points:

$$P1_0 = \begin{pmatrix} 400 \\ 850 \\ 1.89593 \\ 1303.2263 \\ 1443.56264 \\ 1.70562 \\ 1 \end{pmatrix} \qquad P1_{N-1} = \begin{pmatrix} 4500 \\ 850 \\ 0.10467 \\ 1128.16472 \\ 1215.3286 \\ 1.29977 \\ 1 \end{pmatrix}$$

Pressure
Temperature
Specific volume
Specific Internal Energy
Specific Enthalpy
Specific Entropy
Qualty

We have to solve the isentropic expansion for ending pressure. An initial guess of $p_g := 15$ is used.
The root function solves for a state point having X time the specific volume of state point 1

$p_i := \text{root}\left[\text{ST\_ptdata}\left[p_g, \left(P1_i\right)_5, 5, 1\right]_2 - \left(P1_i\right)_2 \cdot X, p_g\right]$ Solve for end of expansion pressure.

$P2_i := \text{ST\_ptdata}\left[p_i, \left(P1_i\right)_5, 5, 1\right]$ Now calculate expansion states array

Following the exhaust state is figured two diferent ways. There is a debate on how exhaust state should be figured. My theodynamic books are contridictory on this also. On one hand we have the conservation of energy law. The engine should reject all energy not converted to work. On the other hand we have valve processes arestated as being throttling processes. Here I just figured it both ways. The one quistion I have: Is constant pressure work a conversion of heat to work?. A motor does no conversion and this process would then be a motor. The work was produced in the boiler as the steam was generated and heated then utilized in a motor. Maybe.

This first analysis treats valves as a throttling process (no change in enthalpy)

$Hx_i := \left(P2_i\right)_4$ — Exhaust enthalpy .. same as end of expansion enthalpy

$P3_i := \text{ST\_ptdata}\left(15, Hx_i, 4, 1\right)$ — Exhaust state.

initial pressure $\left(P1_i\right)_0 =$	expansion pressure $\left(P2_i\right)_0 =$	expansion temperature $\left(P2_i\right)_1 =$	exhaust temperature $\left(P3_i\right)_1 =$	exhaust quality $\left(P3_i\right)_6 =$
400	49.73496	350.2866	336.94003	1
532.25806	66.32745	350.94677	330.93824	1
664.51613	83.00708	351.70854	324.82538	1
796.77419	99.75039	352.49723	318.53053	1
929.03226	116.5819	353.35291	312.09323	1
1061.29032	133.47824	354.22395	305.46541	1
1193.54839	151.0559	358.98501	299.35505	1
1325.80645	169.65637	368.25938	293.81198	1
1458.06452	188.54797	376.89484	287.89386	1
1590.32258	207.7221	384.99225	281.62162	1
1722.58065	227.30935	392.68193	275.11665	1
1854.83871	247.14247	399.95847	268.25122	1
1987.09677	267.29322	406.90002	261.09156	1
2119.35484	287.76729	413.54823	253.64468	1
2251.6129	308.57016	419.93739	245.91464	1
2383.87097	329.70684	426.09599	237.90291	1
2516.12903	351.18154	432.04783	229.6086	1
2648.3871	372.99747	437.81293	221.02876	1
2780.64516	395.15664	443.40823	213.03421	0.99956
2912.90323	418.20881	448.97798	213.03421	0.99508
3045.16129	441.31536	454.32845	213.03421	0.99035
3177.41935	464.85142	459.56125	213.03421	0.98546
3309.67742	488.83212	464.6875	213.03421	0.9804
3441.93548	513.27226	469.717	213.03421	0.97515
3574.19355	538.1859	474.65824	213.03421	0.96971
3706.45161	563.58555	479.51854	213.03421	0.96407
3838.70968	589.48137	484.30399	213.03421	0.95822
3970.96774	615.87995	489.01946	213.03421	0.95215
4103.22581	642.78292	493.66852	213.03421	0.94585
4235.48387	670.18532	498.25336	213.03421	0.93932
4367.74194	698.07365	502.77469	213.03421	0.93254
4500	726.42374	507.23159	213.03421	0.92552

This second analysis figures the exhaust enthalpy to the conservation of energy law.
heat rejected = heat_in - work_out

$Hx_i := \left(P2_i\right)_4 - \left[\left(P2_i\right)_0 - 15\right] \cdot \left(P2_i\right)_2 \cdot \frac{144}{\boldsymbol{J}}$ Exhaust enthalpy .. end of expansion enthalpy - const pressure work P V / J

$P3_i := ST\_ptdata\left(15, Hx_i, 4, 1\right)$ Exhaust state.

initial pressure $\left(P1_i\right)_0 =$	expansion pressure $\left(P2_i\right)_0 =$	expansion temperature $\left(P2_i\right)_1 =$	exhaust temperature $\left(P3_i\right)_1 =$	exhaust quality $\left(P3_i\right)_6 =$
400	49.73496	350.2866	213.03421	0.99821
532.25806	66.32745	350.94677	213.03421	0.989
664.51613	83.00708	351.70854	213.03421	0.98251
796.77419	99.75039	352.49723	213.03421	0.97733
929.03226	116.5819	353.35291	213.03421	0.97289
1061.29032	133.47824	354.22395	213.03421	0.96887
1193.54839	151.0559	358.98501	213.03421	0.96511
1325.80645	169.65637	368.25938	213.03421	0.96147
1458.06452	188.54797	376.89484	213.03421	0.95788
1590.32258	207.7221	384.99225	213.03421	0.9543
1722.58065	227.30935	392.68193	213.03421	0.95075
1854.83871	247.14247	399.95847	213.03421	0.94714
1987.09677	267.29322	406.90002	213.03421	0.9435
2119.35484	287.76729	413.54823	213.03421	0.9398
2251.6129	308.57016	419.93739	213.03421	0.93603
2383.87097	329.70684	426.09599	213.03421	0.93218
2516.12903	351.18154	432.04783	213.03421	0.92826
2648.3871	372.99747	437.81293	213.03421	0.92423
2780.64516	395.15664	443.40823	213.03421	0.92011
2912.90323	418.20881	448.97798	213.03421	0.91597
3045.16129	441.31536	454.32845	213.03421	0.91166
3177.41935	464.85142	459.56125	213.03421	0.90722
3309.67742	488.83212	464.6875	213.03421	0.90266
3441.93548	513.27226	469.717	213.03421	0.89796
3574.19355	538.1859	474.65824	213.03421	0.89311
3706.45161	563.58555	479.51854	213.03421	0.8881
3838.70968	589.48137	484.30399	213.03421	0.88293
3970.96774	615.87995	489.01946	213.03421	0.87759
4103.22581	642.78292	493.66852	213.03421	0.87207
4235.48387	670.18532	498.25336	213.03421	0.86635
4367.74194	698.07365	502.77469	213.03421	0.86044
4500	726.42374	507.23159	213.03421	0.85433