ME 201
Thermodynamics

Users Guide for steam.m

The MATLAB function, steam.m, provides the thermodynamic properties for steam much as they are represented by the steam tables. To access this function include it in your working directory. To use the function in a MATLAB script file, the general form of the function call is

\[ [T, P, v, h, s, Q, L] = \text{steam}(\text{ISTM}, T, P, v, h, s, Q, L) \]

All variables in the argument-in list (in the parentheses following steam) must have been previously defined in the program. These variables are defined as follows:

**ISTM:** Integer flag that controls what thermodynamic variables are treated as known and which ones are unknown. It should be assigned a value of 1, 2, 3, 4, or 5 depending on the knowns and unknowns.
- ISTM=1 - Calculates h, s, v given T,P, L, and Q. If L is set to -1, the fluid phase will be determined. If the temperature is equal to the saturation temperature at the specified pressure, the fluid phase is assumed to be saturated liquid.
- ISTM = 2 - Calculates P, h, s, and v given T, L, and Q. Used primarily for a two phase mixture when the temperature is known.
- ISTM = 3 - Calculates T, h, s, and v given P, L, and Q. Used primarily for a two phase mixture when the pressure is known.
- ISTM = 4 - Calculates T, h, v, L, and Q given P and s. Used primarily for a state following an isentropic process.
- ISTM = 5 - Calculates T, s, v, L, and Q given P and h.

**T:** Temperature in degrees Celsius (°C).
**P:** Pressure in MPa.
**v:** Specific volume in m³/kg.
**h:** Enthalpy in kJ/kg.
**s:** Entropy in kJ/(kg⋅K).
**Q:** Quality of steam. Q = -1 when quality is not applicable, e.g. for superheated vapor or subcooled liquid.
**L:** Fluid phase index. Gives the fluid phase of the steam as follows:
- L = -1 Unknown
- L = 1 Subcooled Liquid
- L = 2 Two Phase Mixture
- L = 3 Superheated Vapor
- L = 4 Saturated Liquid
- L = 5 Saturated Vapor

Because the way that MATLAB handles local and global variables with its functions, the function call does not have to use the precise variables names given above.
In general, steam.m reproduces steam table results to within 1%.

Two examples have been put together as MATLAB script files, Example1.m and Example2.m

```matlab
% EXAMPLE 1 for steam.m
%
% Determine the properties and fluid phase for water at 350 kPa and 300 C.
%
% First assign the variables in the argument-in list
%
T=300;
P=0.350;
% Note that pressure has been converted to MPa
Q=-1;
L=-1;
ISTM=1;
% Note that ISTM=1 case has been chosen
h=0;
s=0;
v=0;
% Note that h, s, and v are unknown for the example, but must be assigned some arbitrary value.
%
% Now call the function
%
[T,P,v,h,s,Q,L]=steam(ISTM,T,P,v,h,s,Q,L);
%
% Now display the results
%
str=sprintf('Results of Example #1 Steam Calculations');
disp(str);
str=sprintf('Temperature: %7.2f C',T);
disp(str);
str=sprintf('Pressure: %7.2f MPa',P);
disp(str);
str=sprintf('Specific Volume: %9.4f m^3/kg',v);
disp(str);
str=sprintf('Enthalpy: %7.2f kJ/kg',h);
disp(str);
str=sprintf('Entropy: %7.2f kJ/kg K',s);
disp(str);
str=sprintf('Quality: %3i',Q);
disp(str);
str=sprintf('Fluid Phase Index: %2i',L);
disp(str);
```
Results of Example #1 Steam Calculations
Temperature: 300.00 C
Pressure: 0.35 MPa
Specific Volume: 0.7495 m^3/kg
Enthalpy: 3067.50 kJ/kg
Entropy: 7.63 kJ/kg K
Quality: -1
Fluid Phase Index: 3

% EXAMPLE 2 for steam.m
% Determine the properties and fluid phase for water at 350 kPa
% and an entropy of 4 kJ/kg K.
% First assign the variables in the argument-in list
P1=0.350;
s1=4.0;
% Note that pressure has been converted to MPa
L1=-1;
ICASE=4;
% Note that ISTM=1 case has been chosen
T1=0;
h1=0;
v1=0;
Q1=0;
% Note that T1, h1, v1, and Q1 are unknown for the example, but must
% be assigned some arbitrary value.
% Now call the function
[T1,P1,v1,h1,s1,Q1,L1]=steam(ICASE,T1,P1,v1,h1,s1,Q1,L1);
% Note that we have used different variable names than those in the
% standard function call.
% Now display the results
str=sprintf('Results of Example #2 Steam Calculations');
disp(str);
str=sprintf('Temperature: %7.2f C',T1);
disp(str);
str=sprintf('Pressure: %7.2f MPa',P1);
disp(str);
str=sprintf('Specific Volume: %9.4f m^3/kg',v1);
disp(str);
str=sprintf('Enthalpy: %7.2f kJ/kg',h1);
disp(str);
str=sprintf('Entropy: %7.2f kJ/kg K',s1);
disp(str);
str=sprintf('Quality: %3i',Q1);
disp(str);
str=sprintf('Fluid Phase Index: %2i',L1);
disp(str);

Results of Example #2 Steam Calculations
Temperature: 138.87 C
Pressure: 0.35 MPa
Specific Volume: 0.2292 m^3/kg
Enthalpy: 1520.76 kJ/kg
Entropy: 4.00 kJ/kg K
Quality: 4.361841e-001
Fluid Phase Index: 2

Finally, to demonstrate the internal consistency of the function Example #2 will be re-run with an entropy of 7.63 kJ/(kg K) (the value calculated in Example #1)

Results of Example #2a Steam Calculations
Temperature: 300.36 C
Pressure: 0.35 MPa
Specific Volume: 0.7500 m^3/kg
Enthalpy: 3068.24 kJ/kg
Entropy: 7.63 kJ/kg K
Quality: -1
Fluid Phase Index: 3