Hey, what's going on?

Water Thermodynamic Properties

Posted by Syeilendra Pramuditya on August 20, 2011

Update+Fortran code Click here

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This post has been cited in these scienti c articles:

1. Numerical investigation of heat transfer in extended surface microchannels, published in International Journal of Heat and Mass Transfer (2016)
2. Dual-pulse nonlinear photoacoustic technique: a practical investigation, published in Biomedical Optics Express (2015)
3. Quanti cation of cooling channel heat transfer in low pressure die casting, Master Thesis at the University of British Columbia (2014)
4. Stanford University Mechanical Engineering Design Proposal
5. Investigating a New Approach for Harvesting Low-grade Thermal Energy Using an Electrochemical System, Research Poster, The Ohio State University
6. DESARROLLO DE UN PRODUCTO INNOVADOR PARA LA PRODUCCIÓN DE HIELO EN EL REFRIGERADOR DOMÉSTICO, THESIS, UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

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There are many empirical and analytical correlations have been developed for thermodynamic properties of water. These correlations generally can be found from scienti c papers as well as text books.

Correlations presented in this article are **polynomial t** to data obtained from XSteam library for Matlab. XSteam itself is a kind of digital library of water properties based on the International Association for Properties of Water and Steam Industrial Formulation 1997 (IAPWS IF-97). These polynomial correlations are meant to be used in computer codes, and they are valid under the following conditions:

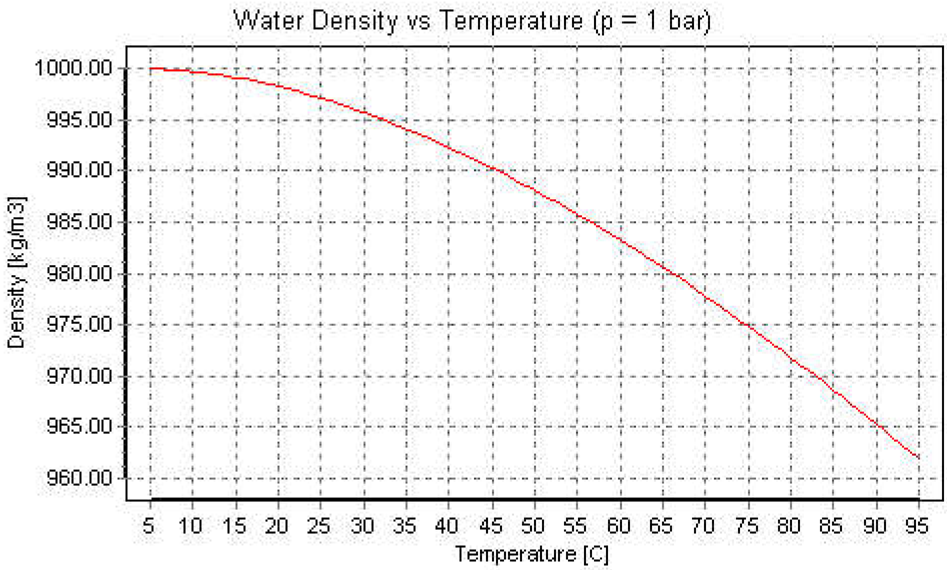
$p = 1 \text{ bar}$

$5\,C \leq T \leq 95\,C$

or equivalently:

$278.15\ K \leq T \leq 368.15\ K$

Water density as a function of temperature (p = 1 bar)

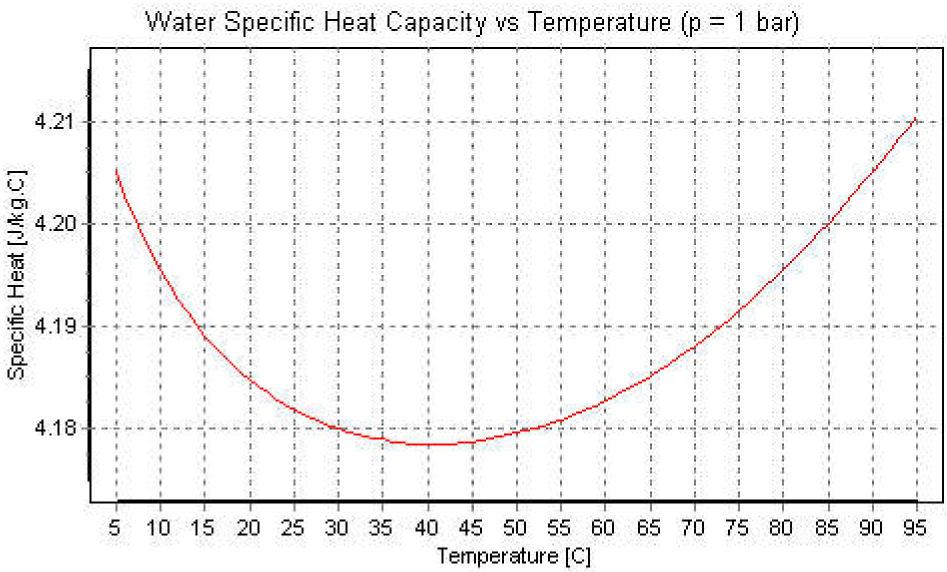


Polynomial t:

$\rho(T) = 1001.1 - 0.0867T - 0.0035T^2$ (T in Celcius, unit is kg/m3)

$\rho(T) = 765.33 + 1.8142T - 0.0035T^2$ (T in Kelvin, unit is kg/m3)

Water speci c heat capacity as a function of temperature (p = 1 bar)

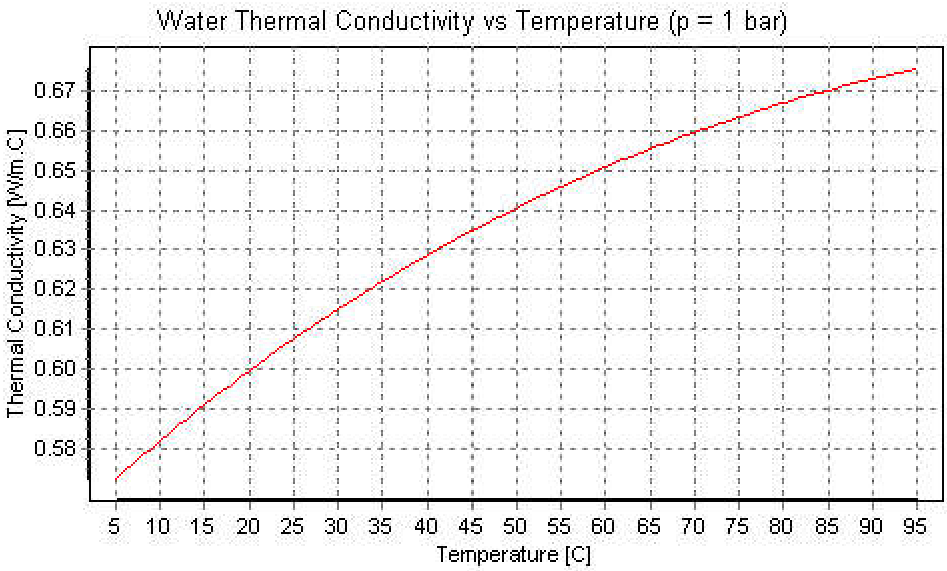


Polynomial t:

$C_p(T) = 4.214 - 2.286 \times 10^{-3}T + 4.991 \times 10^{-5}T^2 - 4.519 \times 10^{-7}T^3 + 1.857 \times 10^{-9}T^4$ (T in Celcius, unit is kJ/kg.C)

$C_p(T) = 28.07 - 0.2817T + 1.25 \times 10^{-3}T^2 - 2.48 \times 10^{-6}T^3 + 1.857 \times 10^{-9}T^4$ (T in Kelvin, unit is kJ/kg.K)

Water thermal conductivity as a function of temperature (p = 1 bar)

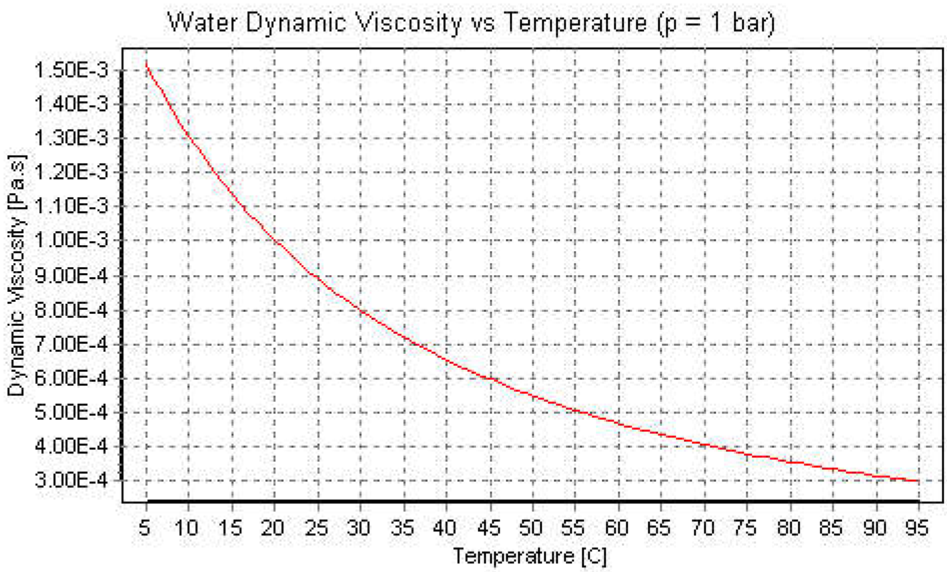


Polynomial t:

$k(T) = 0.5636 + 1.946 \times 10^{-3} T - 8.151 \times 10^{-6} T^2$ (T in Celcius, unit is W/m.C)

$k(T) = -0.5752 + 6.397 \times 10^{-3} T - 8.151 \times 10^{-6} T^2$ (T in Kelvin, unit is W/m.K)

Water dynamic viscosity as a function of temperature (p = 1 bar)



Polynomial t:

$\mu(T) = 1.684 \times 10^{-3} - 4.264 \times 10^{-5} T + 5.062 \times 10^{-7} T^2 - 2.244 \times 10^{-9} T^3$ (T in Celcius, unit is Pa.s)

$\mu(T) = 9.67 \times 10^{-2} - 8.207 \times 10^{-4} T + 2.344 \times 10^{-6} T^2 - 2.244 \times 10^{-9} T^3$ (T in Kelvin, unit is Pa.s)

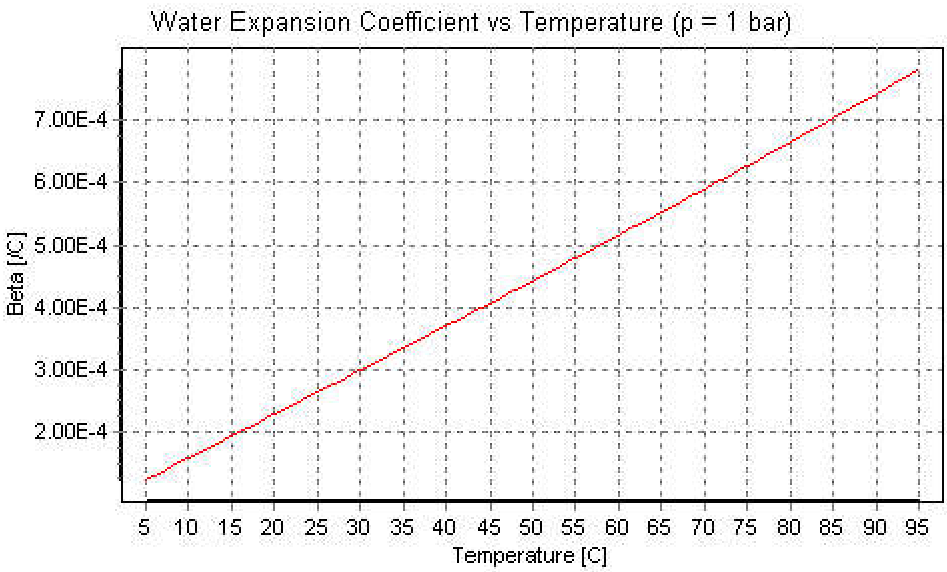
Water volumetric thermal expansion coe cient as a function of temperature (p = 1 bar)

The volumetric thermal expansion coe cient is evaluated from the density equation, as described in this article.

Polynomial   t:

$\beta(T) = 7.957 \times 10^{-5} + 7.315 \times 10^{-6} T$ (T in Celcius, unit is /C)

$\beta(T) = -1.908 \times 10^{-3} + 7.318 \times 10^{-6} T$ (T in Kelvin, unit is /K)



Related links:

- Fortran code to calculate water thermodynamic properties
- Liquid Sodium Thermodynamic and Transport Properties
- Water properties online calculator
- http://www. uidprop.com

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This entry was posted on August 20, 2011 at 4:36 pm and is   led under nuclear engineering. Tagged: Water density, Water dynamic viscosity, Water expansion coe   cient, water properties, Water speci c heat capacity, Water thermal conductivity, water thermodynamic properties. You can follow any responses to this entry through the RSS 2.0 feed. You can leave a response, or trackback from your own site.

10 Responses to “Water Thermodynamic Properties”

1. ### *theanphibian (@theanphibian)* said

   September 23, 2011 at 1:11 am
   I’m sure this will be useful to someone. That’s cool of you to post it.

Syeilendra said..
Glad to know that my post might be useful to somebody, thanks! 🙂

Reply

- ## *Paulo* said

  April 4, 2013 at 10:22 pm
  And so it was… so useful to me. Thanks Syeilendra

  Syeilendra said..
  Glad to hear that

- ## *Unknown* said

  May 12, 2016 at 4:50 am
  what are your references for these equations?

  Syeilendra said..
  it's clearly written there >> Correlations presented in this article are polynomial t to data obtained from XSteam library for Matlab. XSteam itself is a kind of digital library of water properties based on the International Association for Properties of Water and Steam Industrial Formulation 1997 (IAPWS IF-97).

2. ## *sauarav* said

   September 5, 2013 at 5:27 pm
   can u tell me wat realtion v shud use if p=1atm

   Syeilendra said..
   You can use the equations shown in this post, since 1 atm approximately equals to 1 bar.

   Reply

3. ## *Fred Jones* said

   November 8, 2013 at 7:10 pm
   Very useful to me, thanks for posting! (I am an amateur winemaker and I wanted to know how much wine would expand and contract in volume with changes in temperature within a certain range.)

   Syeilendra said..
   Good to know it is useful, you welcome.

Reply

4. *JOE Wong* said

January 19, 2016 at 4:17 am
When I use the above equation to calculate the water speci c heat capacity in 5C and 278.15K, the result is di erence which is 4.2038 and 4.1709. The di erence is signi cant. How do you get the function?

Syeilendra said..
The more accurate are the Celcius ones. I get the equations by curve tting from the original XSteam library.

Reply

- *JOE Wong* said

  January 20, 2016 at 5:25 am
  Thank you. I will use the Celcius ones. it is useful.

5. *R K Pal* said

February 25, 2016 at 1:21 pm
Dear Sir, I'm doing the simulation of ow boiling, in my system the operating pressure is 45 bar at which saturation temperature of water is 530 K. The inlet water temperature is 473 K. I have to use properties of water liquid as function of temperature. Can you help me regarding this

Reply

6. *d.pugliesi* said

November 4, 2016 at 5:33 pm
The units of measure for speci c heat in the diagram are wrong. It has to be written "kJ" instead of "J".

Reply

7. *Dotan* said

February 22, 2017 at 7:44 am
Thanks for this review, really helpful.
It seems that in the graph titled "Water speci c heat capacity as a function of temperature (p = 1

bar)", the y-axis units are incorrect. It says J/kg x C, and I think it should be kJ per kg, as is written in the equation under the gure.

Thanks again!

Reply

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