

TOKOVI ENERGIJE I ENERGETSKA EFIKASNOST

VLAŽAN VAZDUH - VEŽBE 11.04.2017.

VLAŽAN VAZDUH

- Vlažan vazduh predstavlja binarnu smešu suvog vazduha i vodene pare. Vodena para se u ovoj mešavini može naći zasićenom ili pregrejanom stanju. Suv vazduh, kao jedna komponenta vlažnog vazduha, i sam predstavlja mešavinu gasova. U Tabeli 1. predstavljen je sastav čistog suvog atmosferskog vazduha.
- I suvi gasovi i vodena para mogu da se posmatraju kao idealni gasovi ako pritisci nisu značajno veći od atmosferskog pritiska.
- Osobine vlažnog vazduha nazivaju se psihrometrijske osobine, a naučno-stručna oblast koja se bavi izučavanjem vlažnog vazduha naziva se **psihrometrija**.
- Kako bi se u potpunosti definisalo termodinamičko stanje binarne mešavine, kao što je to vlažan vazduh, neophodno je poznavanje tri termodinamičke veličine stanja.

Gas	Zapreminski udeo %	Molarna masa po skali C ¹² =12
Azot (N ₂)	78,084	28,0134
Kiseonik (O ₂)	20,948	31,9988
Argon (Ar)	0,934	39,9480
Ugljen-dioksid (CO ₂)	0,031	44,0099
Neon (Ne)	1,82·10 ⁻³	20,1830
Helijum (He)	5,24·10 ⁻⁴	4,0026
Kripton (Kr)	1,14·10 ⁻⁴	83,8000
Ksenon (Xe)	8,7·10 ⁻⁶	131,3000
Vodonik (H ₂)	5·10 ⁻⁵	2,0159
Metan (CH ₄)	1,5·10 ⁻⁴	16,0430
Azot-oksidi (N ₂ O)	5·10 ⁻⁵	44,0128
Ozon (O ₃) - leti	od 0 do 7·10 ⁻⁶	47,9982
Ozon (O ₃) - zimi	od 0 do 2·10 ⁻⁶	47,9982
Azot-dioksid (NO ₂)	od 0 do 2·10 ⁻⁶	46,0055
Sumpor-dioksid (SO ₂)	od 0 do 1·10 ⁻⁴	64,0628
Amonijak (NH ₃)	0 ili u tragovima	17,0306
Ugljen-monoksid (CO)	0 ili u tragovima	28,0106
Jod (I ₂)	od 0 do 1·10 ⁻⁶	253,8088
Radon (Rn)	6·10 ⁻¹⁸	(izotop)

VLAŽAN VAZDUH

- **Temperatura suvog termometra** je temperatura vlažnog vazduha merena običnim termometrom. Ovaj pojam se koristi samo za razlikovanje od temperature vlažnog (mokrog) termometra.
- **Temperatura vlažnog termometra** je temperatura pri kojoj tečnost ili led isparavanjem dovodi adijabatski vazduh do zasićenja.
- **Temperatura tačke rose** - ako se nezasićeni vazduh hladi pri konstantnom pritisku, mešavina će u određenom trenutku dostići temperaturu zasićenja vodene pare i pri tome će se u njoj pojaviti kapi vode.
- **Apsolutna vlažnost** (x) definiše se kao odnos mase vodene pare i mase suvog vazduha u datoj zapremini mešavine.

$$x = \frac{m_v}{m_a}$$

gde su indeksi „a“ i „v“ redom **suvi vazduh** i **vodena para**.

$$x = 0,622 \cdot \frac{p_v}{p_a} = 0,622 \cdot \frac{p_v}{p - p_v}$$

VLAŽAN VAZDUH

- **Relativna vlažnost** (φ , RH) je odnos stvarne mase vodene pare (m_v) u datoj zapremini u odnosu na koja bi se dobila da je vodena para zasićena pri istoj temperaturi suvog termometra i istom pritisku vazduha ($m_{v,sat}$):

$$RH = \frac{m_v}{m_{v,sat}}$$

ili, može da se definiše kao odnos parcijalnog pritiska vodene pare u nezasićenom vazduhu i parcijalnog pritiska zasićene vodene pare iste temperature:

$$RH = \frac{p_v}{p_{v,sat}}$$

Zadatak 1.

Vazduh temperature 24°C i relativne vlažnosti 0,7, greje se u zagrejaču vazduha do temperature 90°C. Odrediti entalpiju (h) i apsolutnu vlažnost vazduha (x) kada napusti grejač.

Rešenje:

Kako bi izračunali entalpiju vazduha neophodno je najpre definisati kolika je apsolutna vlažnost u početnom stanju. Koristeći *softver za vlažan vazduh*, odabirom opcije **Dry bulb temperature & Relative humidity**, dobija se da je za $t = 24^\circ\text{C}$ i $\text{RH} = 70\%$ apsolutna vlažnost $x = 0,01326$.

THERMODYNAMIC PROPERTIES OF MOIST AIR
Version 1.0
Z. Morvaj, D. Gvozdenac
APPLIED INDUSTRIAL ENERGY and ENVIRONMENTAL MANAGEMENT

Selection option
Dry Bulb Temperature & Relative Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	24
Relative humidity [%]	70

Calculate
Reset
Excel

Boundary values

Maximum dry bulb temperature, [oC]	89,7
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Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	24,00
Wet bulb temperature, twb [oC]	20,00
Dew point temperature, tdp [oC]	18,19
Absolute humidity, x [-]	0,01326
Density, ρ_0 [kg/m ³]	1,1630
Enthalpy, h [kJ/kg]	57,85
Vapor pressure, pv [bar]	0,02087
Relative humidity, RH [%]	70,0

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,0301
Thermal Conductivity, lam [W/mK]	0,026329
Dynamic Viscosity, μ_i [Pa s]	18,153E-06
Prandtl Number, Pr [-]	0,701

Zadatak 1.

Vazduh temperature 24°C i relativne vlažnosti 0,7, greje se u zagrejaču vazduha do temperature 90°C. Odrediti entalpiju (h) i apsolutnu vlažnost vazduha (x) kada napusti grejač.

Rešenje:

Uzimajući u obzir da se zagrevanje vazduha u zagrejaču obavlja pri konstantnoj apsolutnoj vlažnosti $x = \text{const.}$ sledi da je za $t = 90^\circ\text{C}$ i $x = 0,01326$, entalpija $h = 126,10 \text{ kJ/kg}$. Pri tome, smo u ovom slučaju koristili opciju softvera **Dry bulb temperature & Absolute humidity**.

THERMODYNAMIC PROPERTIES OF MOIST AIR

Source Exit

Toolbox III-13
Software 6: THERMODYNAMIC PROPERTIES OF MOIST AIR
Version 1.0
(This Software is based on Toolbox III-6)

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Selection option
Dry Bulb Temperature & Absolute Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry Bulb Temperature [oC]	90
Absolute Humidity [-]	0,01326

Calculate
Reset
Excel

Boundary values

Maximum dry bulb temperature, [oC]	99,6
Maximum absolute humidity, [-]	1,45844

Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	90,00
Wet bulb temperature, twb [oC]	34,37
Dew point temperature, tdp [oC]	18,19
Absolute humidity, x [-]	0,01326
Density, ρ_0 [kg/m ³]	0,9516
Enthalpy, h [kJ/kg]	126,10
Vapor pressure, p _v [bar]	0,02087
Relative humidity, RH [%]	3,0

THERMOPHYSICAL PROPERTIES

Specific Heat, c _p [kJ/kgda]	1,0327
Thermal Conductivity, λ_{am} [W/mK]	0,031258
Dynamic Viscosity, μ_i [Pa s]	21,157E-06
Prandtl Number, Pr [-]	0,690

Zadatak 2.

Vlažan vazduh u prostoriji nalazi se na temperaturi 20°C i relativnoj vlažnosti $\varphi=0,5$. Vazduh se potom zagreva do temperature 55°C pri stalnoj apsolutnoj vlažnosti. Izračunati:

- apsolutnu vlažnost vazduha i specifičnu entalpiju pre i posle zagrevanja,
- dovedenu specifičnu količinu toplote.

Rešenje:

a) Korišćenjem softvera dobijeni su sledeći podaci:

$$x_2 = x_1 = 0,00735 \frac{\text{kg}}{\text{kg sv}}$$

$$h_1 = 38,74 \frac{\text{kJ}}{\text{kg sv}}$$

$$h_2 = 74,46 \frac{\text{kJ}}{\text{kg sv}}$$

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Selection option
Dry Bulb Temperature & Relative Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	20
Relative humidity [%]	50

Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	20,00
Wet bulb temperature, twb [oC]	13,69
Dew point temperature, tdp [oC]	9,27
Absolute humidity, x [-]	0,00735
Density, ro [kg/m3]	1,1830
Enthalpy, h [kJ/kg]	38,74
Vapor pressure, pv [bar]	0,01168
Relative humidity, RH [%]	50,0

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,0191
Thermal Conductivity, lam [W/mK]	0,025976
Dynamic Viscosity, mi [Pa s]	18,035E-06
Prandtl Number, Pr [-]	0,702

Boundary values

Maximum dry bulb temperature, [oC]	89,7
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Selection option
Dry Bulb Temperature & Absolute Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry Bulb Temperature [oC]	55
Absolute Humidity [-]	0,00735

Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	55,00
Wet bulb temperature, twb [oC]	24,41
Dew point temperature, tdp [oC]	9,27
Absolute humidity, x [-]	0,00735
Density, ro [kg/m3]	1,0568
Enthalpy, h [kJ/kg]	74,46
Vapor pressure, pv [bar]	0,01168
Relative humidity, RH [%]	7,4

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,0191
Thermal Conductivity, lam [W/mK]	0,028640
Dynamic Viscosity, mi [Pa s]	19,706E-06
Prandtl Number, Pr [-]	0,696

Boundary values

Maximum dry bulb temperature, [oC]	99,6
Maximum absolute humidity, [-]	0,11619

Zadatak 2.

Vlažan vazduh u prostoriji nalazi se na temperaturi 20°C i relativnoj vlažnosti $\varphi=0,5$. Vazduh se potom zagreva do temperature 55°C pri stalnoj apsolutnoj vlažnosti. Izračunati:

- apsolutnu vlažnost vazduha i specifičnu entalpiju pre i posle zagrevanja,
- dovedenu specifičnu količinu toplote.

Rešenje:

b) Dovedena specifična količina toplote je:

$$h_1 = 38,74 \frac{\text{kJ}}{\text{kg sv}} \text{ i } h_2 = 74,46 \frac{\text{kJ}}{\text{kg sv}}$$

$$q = \Delta h = (74,46 - 38,74) = 35,72 \frac{\text{kJ}}{\text{kg sv}}$$

Zadatak 3.

Vlažan vazduh u prostoriji nalazi se na temperaturi 26°C i relativnoj vlažnosti $\varphi=0,6$. Vazduh se potom hladi do temperature 14°C. Izračunati:

- Izračunati apsolutnu vlažnost vazduha i specifičnu entalpiju pre i posle hlađenja,
- Izračunati odvedenu specifičnu količinu toplote,
- Izračunati promenu apsolutne vlažnosti vazduha.

Rešenje:

- Korišćenjem softvera dobijeni su sledeći podaci za apsolutne vlažnosti i entalpije stanja 1 i stanja 2. Ulazni podaci za stanje 1: $t = 26^\circ\text{C}$ i $\varphi = 0,6$, uz korišćenje opcije **Dry bulb temperature & Relative humidity**. Ulazni podaci za stanje 2: $t = 14^\circ\text{C}$ i $\varphi = 1$, uz korišćenje opcije **Dry bulb temperature & Relative humidity**.

$$x_1 = 0,01280 \quad h_1 = 58,73 \text{ kJ/kg}$$

$$x_2 = 0,01010 \quad h_2 = 39,56 \text{ kJ/kg}$$

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Selection option
Dry Bulb Temperature & Relative Humidity

Input data
Absolute pressure, Pa [bar] 1
Dry bulb temperature [oC] 26
Relative humidity [%] 60
Calculate
Reset
Excel

Boundary values
Maximum dry bulb temperature, [oC] 89,7

Output of calculation
THERMODYNAMIC PROPERTIES
Absolute pressure, Pa [bar] 1,000
Dry bulb temperature, tdb [oC] 26,00
Wet bulb temperature, twb [oC] 20,26
Dew point temperature, tdp [oC] 17,64
Absolute humidity, x [-] 0,01280
Density, rho [kg/m3] 1,1555
Enthalpy, h [kJ/kg] 58,73
Vapor pressure, pv [bar] 0,02016
Relative humidity, RH [%] 60,0
THERMOPHYSICAL PROPERTIES
Specific Heat, cp [kJ/kgda] 1,0292
Thermal Conductivity, lam [W/mK] 0,026478
Dynamic Viscosity, mi [Pa s] 18,254E-06
Prandtl Number, Pr [-] 0,701

Toolbox III-13
Software 6: THERMODYNAMIC PROPERTIES OF MOIST AIR
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Selection option
Dry Bulb Temperature & Relative Humidity

Input data
Absolute pressure, Pa [bar] 1
Dry bulb temperature [oC] 14
Relative humidity [%] 100
Calculate
Reset
Excel

Boundary values
Maximum dry bulb temperature, [oC] 89,7

Output of calculation
THERMODYNAMIC PROPERTIES
Absolute pressure, Pa [bar] 1,000
Dry bulb temperature, tdb [oC] 14,00
Wet bulb temperature, twb [oC] 14,00
Dew point temperature, tdp [oC] 14,00
Absolute humidity, x [-] 0,01010
Density, rho [kg/m3] 1,2057
Enthalpy, h [kJ/kg] 39,56
Vapor pressure, pv [bar] 0,01597
Relative humidity, RH [%] 100,0
THERMOPHYSICAL PROPERTIES
Specific Heat, cp [kJ/kgda] 1,0245
Thermal Conductivity, lam [W/mK] 0,025538
Dynamic Viscosity, mi [Pa s] 17,710E-06
Prandtl Number, Pr [-] 0,703

Zadatak 3.

Vlažan vazduh u prostoriji nalazi se na temperaturi 26°C i relativnoj vlažnosti $\varphi=0,6$. Vazduh se potom hladi do temperature 14°C. Izračunati:

- Izračunati apsolutnu vlažnost vazduha i specifičnu entalpiju pre i posle hlađenja,
- Izračunati odvedenu specifičnu količinu toplote,
- Izračunati promenu apsolutne vlažnosti vazduha.

Rešenje:

$$x_1 = 0,01280 \quad h_1 = 58,73 \text{ kJ/kg}$$

$$x_2 = 0,01010 \quad h_2 = 39,56 \text{ kJ/kg}$$

- Odvedena specifična količina toplote je:

$$q = \Delta h = (58,73 - 39,56) = 19,17 \frac{\text{kJ}}{\text{kg sv}}$$

- Promena apsolutne vlažnosti vazduha:

$$\Delta x = x_1 - x_2 = 0,01280 - 0,01010 = 0,0027$$

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Selection option
Dry Bulb Temperature & Relative Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	26
Relative humidity [%]	60

Boundary values

Maximum dry bulb temperature, [oC]	89,7
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Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	26,00
Wet bulb temperature, twb [oC]	20,26
Dew point temperature, tdp [oC]	17,64
Absolute humidity, x [-]	0,01280
Density, rho [kg/m3]	1,1555
Enthalpy, h [kJ/kg]	58,73
Vapor pressure, pv [bar]	0,02016
Relative humidity, RH [%]	60,0

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,0292
Thermal Conductivity, lam [W/mK]	0,026478
Dynamic Viscosity, mi [Pa s]	18,254E-06
Prandtl Number, Pr [-]	0,701

Toolbox III-13
Software 6: THERMODYNAMIC PROPERTIES OF MOIST AIR
Version 1.0
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Selection option
Dry Bulb Temperature & Relative Humidity

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	14
Relative humidity [%]	100

Boundary values

Maximum dry bulb temperature, [oC]	89,7
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Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	14,00
Wet bulb temperature, twb [oC]	14,00
Dew point temperature, tdp [oC]	14,00
Absolute humidity, x [-]	0,01010
Density, rho [kg/m3]	1,2057
Enthalpy, h [kJ/kg]	39,56
Vapor pressure, pv [bar]	0,01597
Relative humidity, RH [%]	100,0

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,0245
Thermal Conductivity, lam [W/mK]	0,025538
Dynamic Viscosity, mi [Pa s]	17,710E-06
Prandtl Number, Pr [-]	0,703

Zadatak 4. – ZAGREVANJE I OVLAŽIVANJE

Dva i po kubna metra drveta se suši na 60°C (temperatura suvog termometra) i 52°C (temperatura vlažnog termometra) i $v_1 = 0,87 \frac{\text{m}^3}{\text{kg sv}}$. Stopa sušenja rezane građe je 12,5 kg vode na sat. Ako je spoljašnji vazduh na 27°C (temperatura suvog termometra) i 80% relativne vlažnosti, koliko je potrebno ubaciti spoljašnjeg vazduh po minuti kako bi se odvela isparena vlaga?

Rešenje:

$$\Delta x = x_2 - x_1 = 94 \frac{\text{g}}{\text{kg}} - 18 \frac{\text{g}}{\text{kg}} = 76 \frac{\text{g}}{\text{kg sv}}$$

$$\text{Stopa sušenja} = \dot{m}_a \cdot \Delta x$$

Odakle je:

$$\dot{m}_a = \frac{12,5 \frac{\text{kg}}{\text{h}}}{0,076 \frac{\text{kg}}{\text{kg sv}}} = 164,5 \frac{\text{kg sv}}{\text{h}}$$

Koristeći sledeću formulu:

$$\dot{m}_a = \frac{\dot{V}}{v_1}$$

sledi da je :

$$\dot{V} = \dot{m}_a \cdot v_1 = 164,5 \frac{\text{kg sv}}{\text{h}} \cdot 0,87 \frac{\text{m}^3}{\text{kg sv}} = 143,1 \frac{\text{m}^3}{\text{h}}$$

Software: THERMODYNAMIC PROPERTIES OF MOIST AIR (Version 1.0)

Selection option: Dry Bulb Temperature & Relative Humidity

Input data:

- Absolute pressure, Pa [bar]: 1
- Dry bulb temperature [°C]: 27
- Relative humidity [%]: 80

Boundary values:

- Maximum dry bulb temperature, [°C]: 89,7

Output of calculation:

THERMODYNAMIC PROPERTIES

- Absolute pressure, Pa [bar]: 1,000
- Dry bulb temperature, tdb [°C]: 27,00
- Wet bulb temperature, twb [°C]: 24,22
- Dew point temperature, tdp [°C]: 23,25
- Absolute humidity, x [-]: 0,01825
- Density, ρ [kg/m³]: 1,1480
- Enthalpy, h [kJ/kg]: 73,68
- Vapor pressure, pv [bar]: 0,02851
- Relative humidity, RH [%]: 80,0

THERMOPHYSICAL PROPERTIES

- Specific Heat, cp [kJ/kgda]: 1,0395
- Thermal Conductivity, lam [W/mK]: 0,026596
- Dynamic Viscosity, mi [Pa s]: 18,236E-06
- Prandtl Number, Pr [-]: 0,700

Software: THERMODYNAMIC PROPERTIES OF MOIST AIR (Version 1.0)

Selection option: Dry & Wet Bulb Temperature

Input data:

- Absolute pressure, Pa [bar]: 1
- Dry bulb temperature [°C]: 60
- Wet bulb temperature [°C]: 52

Boundary values:

- Maximum dry bulb temperature, [°C]: 99,6
- Minimum wet bulb temperature, [°C]: 20,7

Output of calculation:

THERMODYNAMIC PROPERTIES

- Absolute pressure, Pa [bar]: 1,000
- Dry bulb temperature, tdb [°C]: 60,00
- Wet bulb temperature, twb [°C]: 52,00
- Dew point temperature, tdp [°C]: 51,33
- Absolute humidity, x [-]: 0,09435
- Density, ρ [kg/m³]: 0,9935
- Enthalpy, h [kJ/kg]: 306,90
- Vapor pressure, pv [bar]: 0,13171
- Relative humidity, RH [%]: 66,1

THERMOPHYSICAL PROPERTIES

- Specific Heat, cp [kJ/kgda]: 1,1877
- Thermal Conductivity, lam [W/mK]: 0,029340
- Dynamic Viscosity, mi [Pa s]: 18,823E-06
- Prandtl Number, Pr [-]: 0,696

Zadatak 5. HLAĐENJE I ODVLAŽIVANJE

Vlažan vazduh na 50°C (temperatura suvog termometra) i 32% relativne vlažnosti ulazi u toplotni izmenjivač i ohladi se do temperature od 18°C (temperatura suvog termometra). Ukoliko je stopa sušenja 6 kubika crvenog hrasta 4 kg/h, odrediti potrebnu snagu hladnjaka u kW.

Rešenje:

$$\Delta x = x_2 - x_1 = 25,5 \frac{g}{kg} - 13,1 \frac{g}{kg} = 12,4 \frac{g}{kg \text{ sv}}$$

$$\text{Stopa sušenja} = \dot{m}_a \cdot \Delta x$$

Odakle je:

$$\dot{m}_a = \frac{4 \frac{kg}{h}}{0,0124 \frac{kg}{kg \text{ sv}}} = 322,6 \frac{kg \text{ sv}}{h}$$

$$\Delta h = (116,6 - 51,26) = 65,24 \frac{kJ}{kg \text{ sv}}$$

$$\dot{Q} = \Delta h \cdot \dot{m}_a = 21046,4 \frac{kJ}{h} = 5,8 \text{ kW}$$

Software: THERMODYNAMIC PROPERTIES OF MOIST AIR (Version 1.0)

Selection option: Dry Bulb Temperature & Relative Humidity

Input data:

- Absolute pressure, Pa [bar]: 1
- Dry bulb temperature [oC]: 50
- Relative humidity [%]: 32

Boundary values:

- Maximum dry bulb temperature, [oC]: 89,7

Output of calculation:

THERMODYNAMIC PROPERTIES

- Absolute pressure, Pa [bar]: 1,000
- Dry bulb temperature, tdb [oC]: 50,00
- Wet bulb temperature, twb [oC]: 32,84
- Dew point temperature, tdp [oC]: 28,75
- Absolute humidity, x [-]: 0,02556
- Density, ro [kg/m3]: 1,0618
- Enthalpy, h [kJ/kg]: 116,58
- Vapor pressure, pv [bar]: 0,03947
- Relative humidity, RH [%]: 32,0

THERMOPHYSICAL PROPERTIES

- Specific Heat, cp [kJ/kgda]: 1,0535
- Thermal Conductivity, lam [W/mK]: 0,028363
- Dynamic Viscosity, mi [Pa s]: 19,194E-06
- Prandtl Number, Pr [-]: 0,695

Software: THERMODYNAMIC PROPERTIES OF MOIST AIR (Version 1.0)

Selection option: Dry Bulb Temperature & Relative Humidity

Input data:

- Absolute pressure, Pa [bar]: 1
- Dry bulb temperature [oC]: 18
- Relative humidity [%]: 100

Boundary values:

- Maximum dry bulb temperature, [oC]: 89,7

Output of calculation:

THERMODYNAMIC PROPERTIES

- Absolute pressure, Pa [bar]: 1,000
- Dry bulb temperature, tdb [oC]: 18,00
- Wet bulb temperature, twb [oC]: 18,00
- Dew point temperature, tdp [oC]: 18,00
- Absolute humidity, x [-]: 0,01310
- Density, ro [kg/m3]: 1,1871
- Enthalpy, h [kJ/kg]: 51,26
- Vapor pressure, pv [bar]: 0,02062
- Relative humidity, RH [%]: 100,0

THERMOPHYSICAL PROPERTIES

- Specific Heat, cp [kJ/kgda]: 1,0300
- Thermal Conductivity, lam [W/mK]: 0,025870
- Dynamic Viscosity, mi [Pa s]: 17,868E-06
- Prandtl Number, Pr [-]: 0,702

Zadatak 6. ADIJABATSKO HLAĐENJE ILI HLAĐENJE SA ISPARAVANJEM (PROMENA FAZE)

Vazduh stanja u tački 1 (65°C temperatura suvog termometra i 57°C temperatura vlažnog termometra i specifična zapremina $v_1 = 1,15 \frac{\text{m}^3}{\text{kg sv}}$) trpi pad temperature od 3°C , dok prolazi kroz vlažnu drvenu građu. Odredite svojstva vazduha u tački 2 i specifična zapremina ($v_2 = 1,14 \frac{\text{m}^3}{\text{kg sv}}$) i uporediti ih sa onima iz tačke 1. Ako je brzina strujanja vazduha 2 metra u sekundi i površina razmene toplote $1,47\text{m}^2$, odrediti stopu sušenja?

Rešenje:

Iz softvera za date parametre tačke 1 dobijaju se sledeći podaci:

THERMODYNAMIC PROPERTIES OF MOIST AIR
Version 1.0
Z. Morvaj, D. Gvozdenac
APPLIED INDUSTRIAL ENERGY and ENVIRONMENTAL MANAGEMENT

Selection option
Dry & Wet Bulb Temperature

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	65
Wet bulb temperature [oC]	57

Calculate
Reset
Excel

Boundary values

Maximum dry bulb temperature, [oC]	99,6
Minimum wet bulb temperature, [oC]	22,1

Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	65,00
Wet bulb temperature, twb [oC]	57,00
Dew point temperature, tdp [oC]	56,48
Absolute humidity, x [-]	0,12639
Density, ro [kg/m3]	0,9644
Enthalpy, h [kJ/kg]	396,84
Vapor pressure, pv [bar]	0,16888
Relative humidity, RH [%]	67,5

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,2512
Thermal Conductivity, lam [W/mK]	0,029721
Dynamic Viscosity, mi [Pa s]	18,692E-06
Prandtl Number, Pr [-]	0,699

Zadatak 6. ADIJABATSKO HLAĐENJE ILI HLAĐENJE SA ISPARAVANJEM (PROMENA FAZE)

Vazduh stanja u tački 1 (65°C temperatura suvog termometra i 57°C temperatura vlažnog termometra i specifična zapremina $v_1 = 1,15 \frac{\text{m}^3}{\text{kg sv}}$) trpi pad temperature od 3°C , dok prolazi kroz vlažnu drvenu građu. Odredite svojstva vazduha u tački 2 i specifična zapremina ($v_2 = 1,14 \frac{\text{m}^3}{\text{kg sv}}$) i uporediti ih sa onima iz tačke 1. Ako je brzina strujanja vazduha 2 metra u sekundi i površina razmene toplote $1,47\text{m}^2$, odrediti stopu sušenja?

Rešenje:

- a) Iz softvera za date parametre tačke 2 dobijaju se sledeći podaci:

THERMODYNAMIC PROPERTIES OF MOIST AIR
Version 1.0
Z. Morvaj, D. Gvozdenac
APPLIED INDUSTRIAL ENERGY and ENVIRONMENTAL MANAGEMENT

Selection option
Dry & Wet Bulb Temperature

Input data

Absolute pressure, Pa [bar]	1
Dry bulb temperature [oC]	62
Wet bulb temperature [oC]	57

Boundary values

Maximum dry bulb temperature, [oC]	99,6
Minimum wet bulb temperature, [oC]	21,2

Output of calculation

THERMODYNAMIC PROPERTIES

Absolute pressure, Pa [bar]	1,000
Dry bulb temperature, tdb [oC]	62,00
Wet bulb temperature, twb [oC]	57,00
Dew point temperature, tdp [oC]	56,67
Absolute humidity, x [-]	0,12782
Density, ro [kg/m3]	0,9724
Enthalpy, h [kJ/kg]	396,84
Vapor pressure, pv [bar]	0,17047
Relative humidity, RH [%]	78,1

THERMOPHYSICAL PROPERTIES

Specific Heat, cp [kJ/kgda]	1,2539
Thermal Conductivity, lam [W/mK]	0,029529
Dynamic Viscosity, mi [Pa s]	18,579E-06
Prandtl Number, Pr [-]	0,699

Zadatak 6. ADIJABATSKO HLAĐENJE ILI HLAĐENJE SA ISPARAVANJEM (PROMENA FAZE)

Vazduh stanja u tački 1 (65°C temperatura suvog termometra i 57°C temperatura vlažnog termometra i specifična zapremina $v_1 = 1,15 \frac{m^3}{kg\ sv}$) trpi pad temperature od 3°C, dok prolazi kroz vlažnu drvenu građu. Odredite svojstva vazduha u tački 2 i specifična zapremina ($v_2 = 1,14 \frac{m^3}{kg\ sv}$) i uporediti ih sa onima iz tačke 1. Ako je brzina strujanja vazduha 2 m/s i površina razmene toplote 1,47 m², odrediti stopu sušenja?

Rešenje:

b) Stopa sušenja:

$$\text{Stopa sušenja} = \dot{m}_a \cdot \Delta x$$

$$\Delta x = x_2 - x_1 = 127,8 \frac{g}{kg} - 126,4 \frac{g}{kg} = 1,4 \frac{g}{kg\ sv}$$

$$\dot{m}_a = \frac{\dot{V}}{v_2}$$

$$\dot{V} = (A) \cdot v_V \text{ (brzina strujanja vazduha)}$$

$$\dot{V} = (1,47 m^2) \cdot \left(2 \frac{m}{s}\right) = \left(2,94 \frac{m^3}{s}\right)$$

$$\dot{m}_a = \frac{2,94 \frac{m^3}{s}}{1,14 \frac{m^3}{kg\ sv}} = 2,57 \frac{kg\ sv}{s}$$

$$\text{Stopa sušenja} = 2,57 \frac{kg\ sv}{s} \cdot 1,4 \frac{g}{kg\ sv} = 3,6 \frac{g}{s} = 12,96 \frac{kg}{h}$$