Surface condensation & evaporation mass flow

Introduction

Surface condensation occurs when the surface temperature is lower than the dew point of the adjacent air.
A spreadsheet tool for the condensation mass flow calculation is presented.
The tool can be used for the evaporation mass flow from a humid surface to the adjacent air as well.

Surface condensation & evaporation mass flow: formulas

$$q_m = \beta\,(p_{air} - p_{surface}) \quad [\mathrm{kg/m^2 s}]$$

$$\beta = 7.7\ 10^{-09}\ h_c \quad [\mathrm{s/m}]$$

$$q = H\ q_m \quad [\mathrm{W/m^2}]$$

q_m mass flow [kg/m^{2}s]
b vapour diffusion surface coefficient [s/m]
p_{air} air vapour pressure [Pa]
$p_{surface}$ surface saturation vapour pressure [Pa]
h_c convective surface heat transfer coefficient [W/m^{2}K]
q heat generated by the condensation or required by the evaporation [W/m^2]
H water vaporization heat [J/kg] = 2502 kJ/kg (H_2O at 0 °C)
= 2256 kJ/kg (H_2O at 100 °C)

References: "Introduction to Heat Transfer", Frank P. Incropera, David P. Dewitt, 1996
"Bouwfysica 1. Warmte- en massatransport", Hugo Hens, 1992

Surface condensation & evaporation mass flow: Spreadsheet tool

The spreadsheet surface_condensation_evaporation_mass_flow.xlsm allows to calculate the condensation and evaporation mass flow.

CONDENSATION

case	air temperature °C	relative humidity %	saturation vapour pressure Pa	vapour pressure Pa	dewpoint °C	surface temperature °C	surface saturation vapour pressure Pa	convective surface heat transfer coefficient W/m^2K	vapour diffusion surface coefficient s/m	condensation mass flow kg/m^2s	condensation heat generation W/m^2
1	20.0	80.0	2336	1869	16.4	10.0	1227	3.0	2.31.E-08	0.0000148	36.7460603
2	28.0	70.0	3777	2644	22.0	18.0	2062	3.0	2.31.E-08	0.0000134	33.0261827
3	20.0	70.0	2336	1635	14.3	10.0	1227	3.0	2.31.E-08	0.0000094	23.3776135
4	35.0	80.0	5617	4494	31.0	1.0	657	3.0	2.31.E-08	0.0000886	221.5344302
5	40.0	80.0	7367	5893	35.8	1.0	657	3.0	2.31.E-08	0.0001210	302.3464580

EVAPORATION

case	air temperature °C	relative humidity %	saturation vapour pressure Pa	vapour pressure Pa	dewpoint °C	humid surface temperature °C	surface saturation vapour pressure Pa	convective surface heat transfer coefficient W/m^2K	vapour diffusion surface coefficient s/m	evaporation mass flow kg/m^2s	evaporation heat requirement W/m^2
1	20.0	80.0	2336	1869	16.4	28.0	3777	3.0	2.31.E-08	0.0000441	107.2280364
2	28.0	70.0	3777	2644	22.0	30.0	4239	3.0	2.31.E-08	0.0000369	89.4983479
3	20.0	60.0	2336	1402	12.0	35.0	5617	4.0	3.08.E-08	0.0001298	313.6667337
4	20.0	60.0	2336	1402	12.0	25.0	3165	10.0	7.70.E-08	0.0001358	331.3566911
5	0.0	90.0	611	550	-1.3	35.0	5617	10.0	7.70.E-08	0.0003902	942.6037305