

## Formation avancée EINSTEIN

### Module AT-02: Points délicats Part c: procédés de séchage

### Fiche pour les stagiaires

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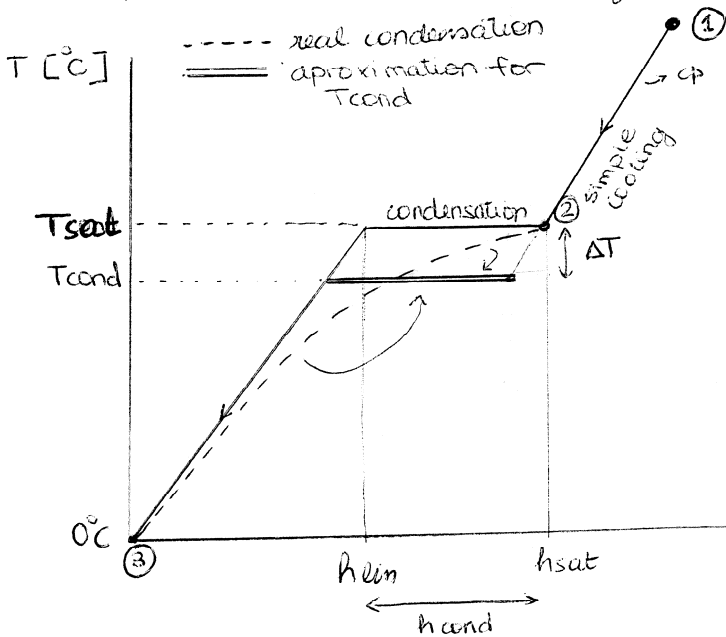
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# **1 Indications pour la modélisation de l'air humide (par exemple résidus de chaleur de procédés de séchage)**

## ATOZ TRICKY THINGS

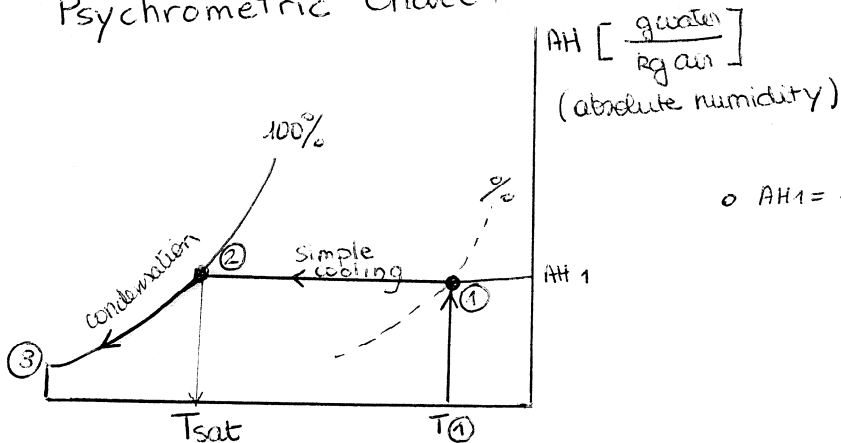
C: DRYERS

## Chapter 4: Representation of humid air in EINSTEIN:



Humid air is cooled down. At the temperature of dew point, vapour contained in the air starts to condense. Condensation does not take place at constant temperature: temperature decreases. The real line of condensation is a curve. -----

### Psychrometric Chart:



o  $AH_1 = AH_2$  (simple cooling)

## Approximation

Oxidation  
In order to fix a Tcondensation, it will be assumed that it is  $\Delta T^{\circ}\text{C}$  lower than  $T_{\text{saturation}}$ .

## Exercice

### ① Humid Air

$T = 47^\circ\text{C}$  <sup>water</sup>  
 $AH = 27,02 \text{ g}^{\text{water}}/\text{kg air}$   
 $RH = 37,1\%$   
 $h = 115,245 \text{ kJ/kg}$   
 $DP = 29,9^\circ\text{C} \rightarrow \text{Saturation}$   
 $WB = 33,0^\circ\text{C}$

AH: absolute humidity  
RH: relative humidity  
h: enthalpy  
DP: dew point  
WB: wet bulb

### ② Dew Point (start of condensation)

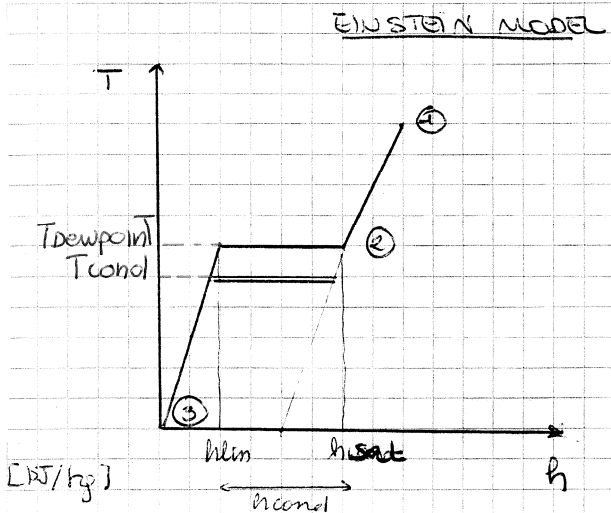
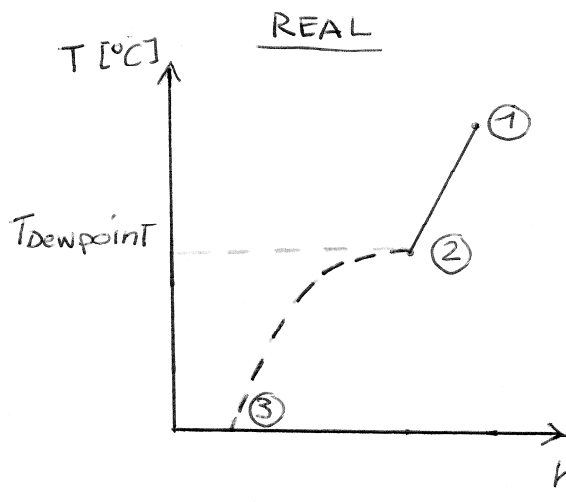
$T = 29,9^\circ\text{C}$   
 $RH = 100\%$   
 $AH = 27,02 \text{ g}^{\text{water}}/\text{kg air}$   
 $h = 98,120 \text{ kJ/kg}$   
 $DP = 29,9^\circ\text{C}$   
 $WB = 29,9^\circ\text{C}$

### ③ Final temperature

$T = 0^\circ\text{C}$   
 $RH = 100\%$   
 $AH = 3,76 \text{ g/kg}$   
 $h = 9,493 \text{ kJ/kg}$   
 $DP = 0^\circ\text{C}$   
 $WB = 0^\circ\text{C}$

## Assumptions

$$c_{pl} \approx c_{\text{air}} = 1 \text{ kJ/kg}$$



At  $T = 0^\circ\text{C}$ , the fluid has an enthalpy  $h > 0 \text{ kJ/kg}$ . However, in EINSTEIN it has to be modelled as if at  $T = 0^\circ\text{C} \rightarrow$

$$h = 0 \text{ kJ/kg}$$

REAL

$$h_1 = 115,245 \text{ kJ/kg}$$

$$h_2 = h_{\text{sat}} = 98,120 \text{ kJ/kg}$$

$$h_3 = 9,493 \text{ kJ/kg}$$

EINSTEIN MODEL

$$h_1' = h_1 - h_3 = 115,245 - 9,493 = 105,75 \text{ kJ/kg}$$

$$h_2' = h_2 - h_3 = 98,120 - 9,493 = 88,63 \text{ kJ/kg}$$

$$h_3' = 0$$

$$h_{\text{lim}} = c_{\text{p,air}} T_{\text{sat}} = 1 \times 29,9 = 29,9 \text{ kJ/kg}$$

$$h_{\text{cond}} = h_{\text{sat}} - h_{\text{lim}} = 88,63 - 29,9 = 58,73 \text{ kJ/kg}$$

$$\Delta T = T_{\text{dewpoint}} - T_{\text{cond}}$$

$$\text{We choose } \Delta T = 5 \text{ K}$$

$$T_{\text{cond}} = 29,9 - 5 = 24,9^\circ\text{C}$$