TOELICHTING BIJ SO_3 DAUWPUNTSBEPALING VIA CALCULATOR

INHOUD

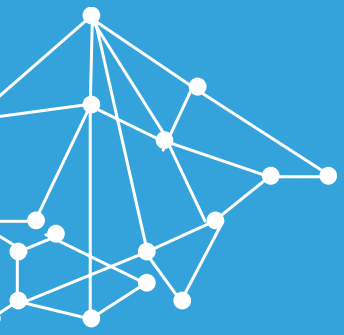
SO_X-metingen en aanpassing compendiummethode LUC/III/008

H_2SO_4 vorming en dauwpunt (IFK)

Dauwpuntscalculator

Vergelijkingen en referenties

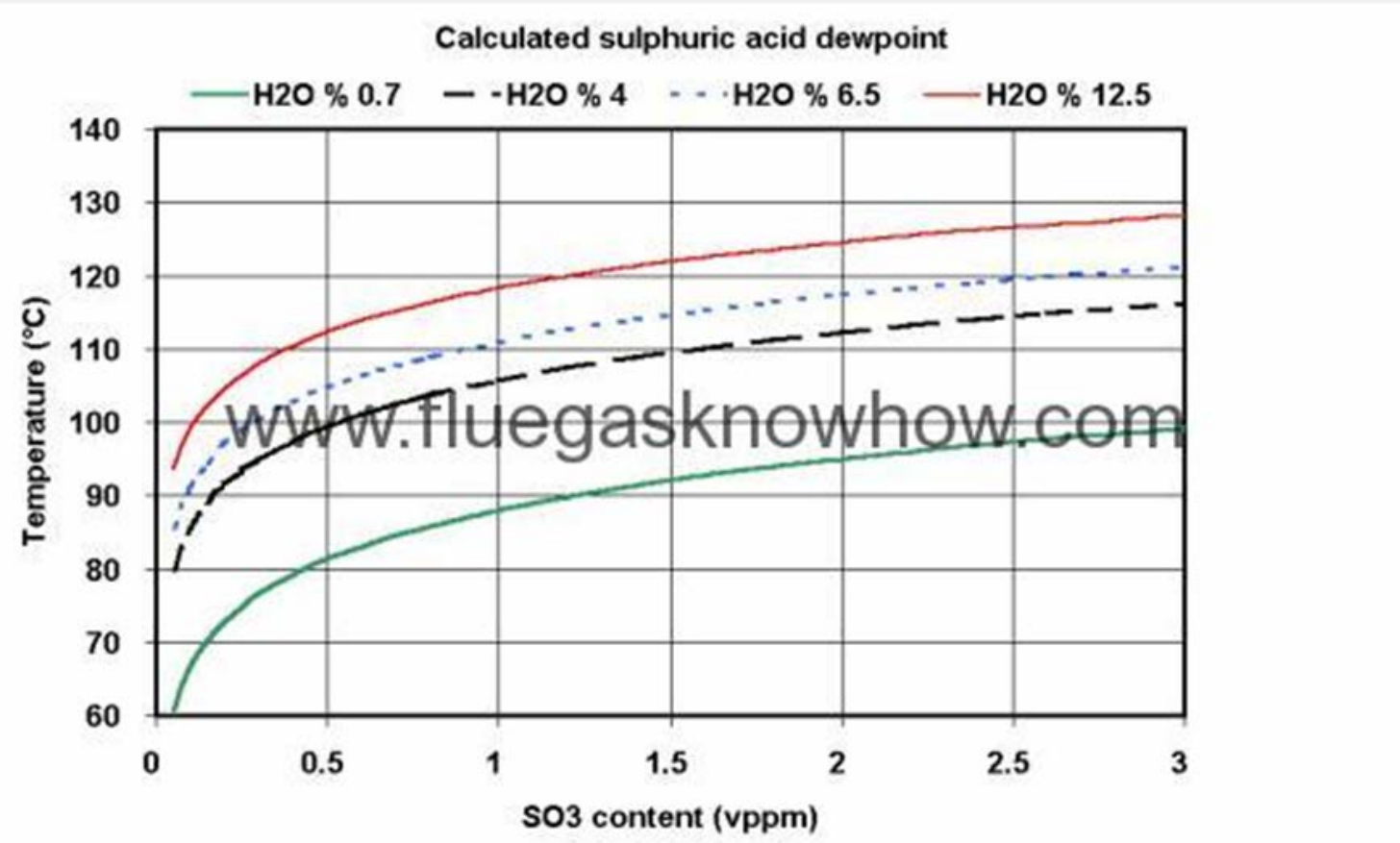
Keuze van filtermateriaal bij bemonstering SO_3



SO_X-METINGEN EN AANPASSING COMPENDIUMMETHODE LUC/III/008

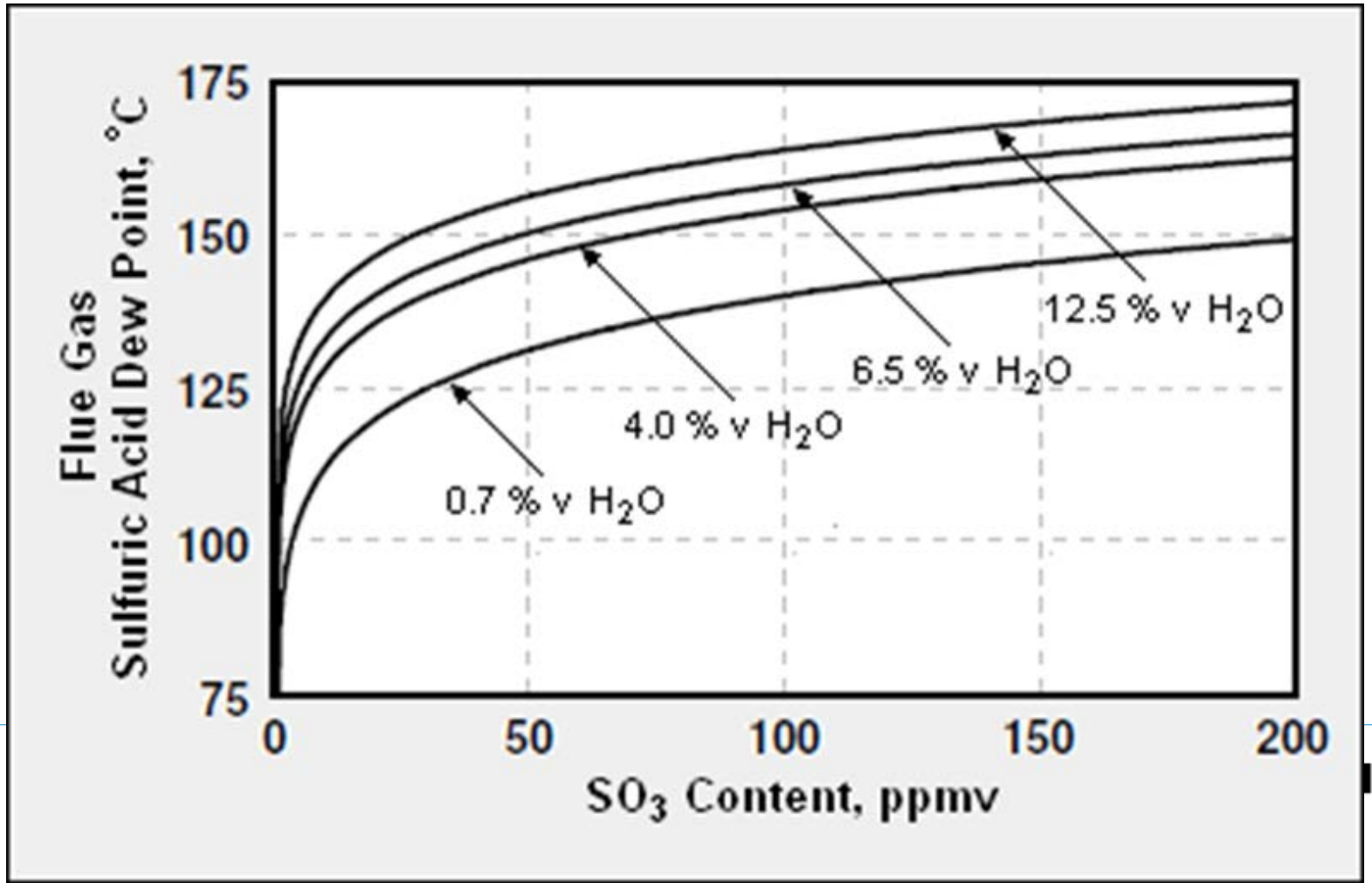
SO_X-meting in aanwezigheid van SO_3:

- Dauwpunt van zwavelzuur is functie van het watergehalte en de SO_3-concentratie in de gasstroom
- http://fluegasknowhow.com/online-calculators/flue-gas-sox-acid-dew-point-calculator/



SO_X-METINGEN EN AANPASSING COMPENDIUMMETHODE LUC/III/008

"Calculated sulfuric acid dew points of typical combustion flue gases, as a function of sulfur trioxide content, and water vapor" (bron: http://chemengineering.wikispaces.com/Acid+dewpoint)



SO_X-METINGEN EN AANPASSING COMPENDIUMMETHODE LUC/III/008

SO_X-meting in aanwezigheid van SO_3:

- Temperatuur van 120°C niet steeds voldoende om condensatie te vermijden!
- Aanpassing LUC-methode:
  - Temperatuur steeds op minstens 120°C en (in plaats van of) 20°C hoger dan het zuurdauwpunt
  - Aantonen dat temperatuur minstens 20°C boven het zuurdauwpunt is of standaard “veilige” temperatuur van 200°C

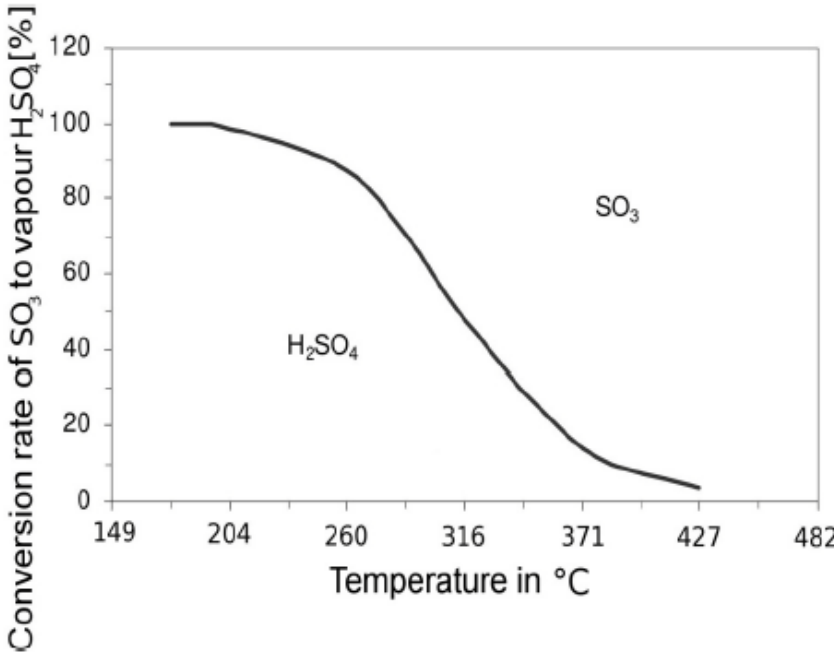
H_2SO_4 formation and dew point (1/3)

SO_3 and H_2O form vapour sulfuric acid H_2SO_4 [4]:

$$SO_3^{(g)} + H_2O^{(g)} \rightarrow H_2SO_4^{(g)}$$

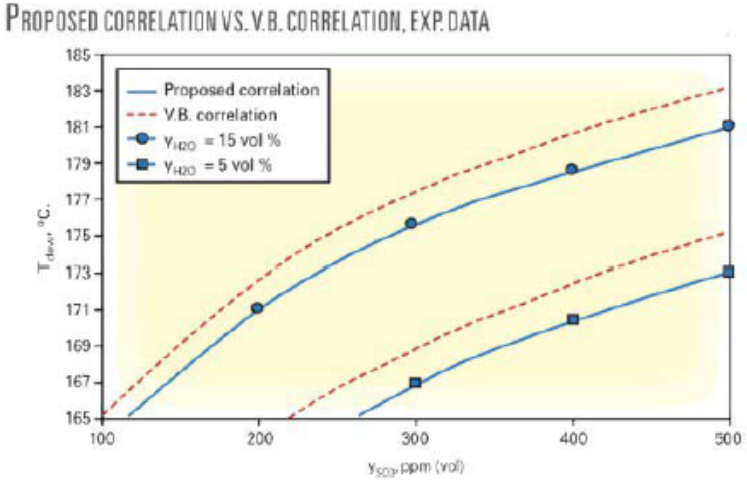
- Formation starts at about 400°C.

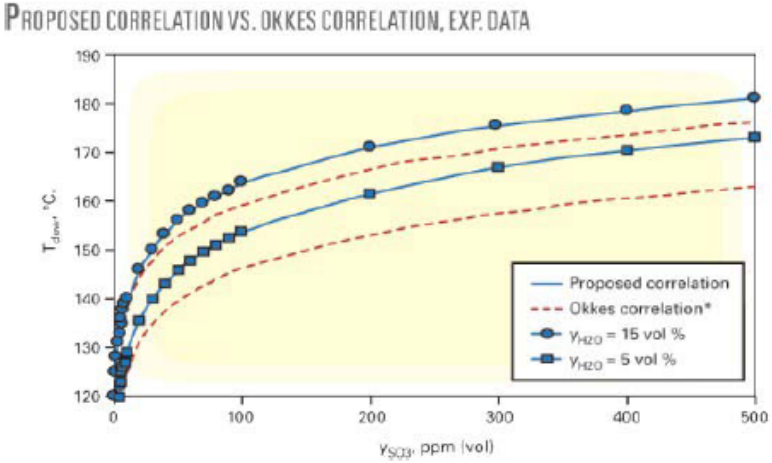
- At about 200°C almost all SO_3 is consumed.



H_2SO_4 formation and dew point (2/3)

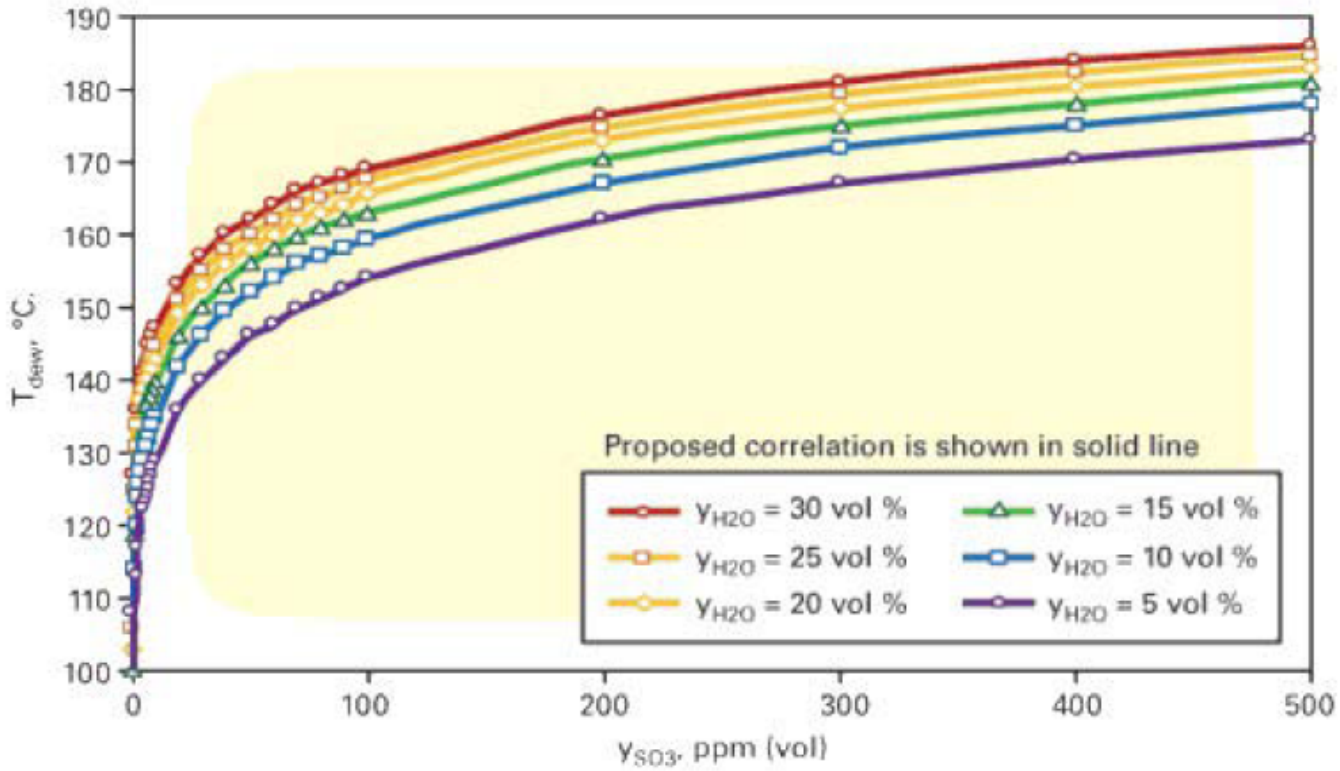
- Condensation of H_2SO_4 when temperature falls below acid dew point temperature: $T_{Dew} = f(p_{SO3}, p_{H2O})$
- T_{Dew} calculation at IFK according to Zarenezhad [5]
- T_{Dew} formerly calculated according to Verhoff/Banchero [6] or Okkes [7]:
  - Verhoff/Banchero equation overpredicts T_{Dew}
  - Okkes equation underpredicts T_{Dew}





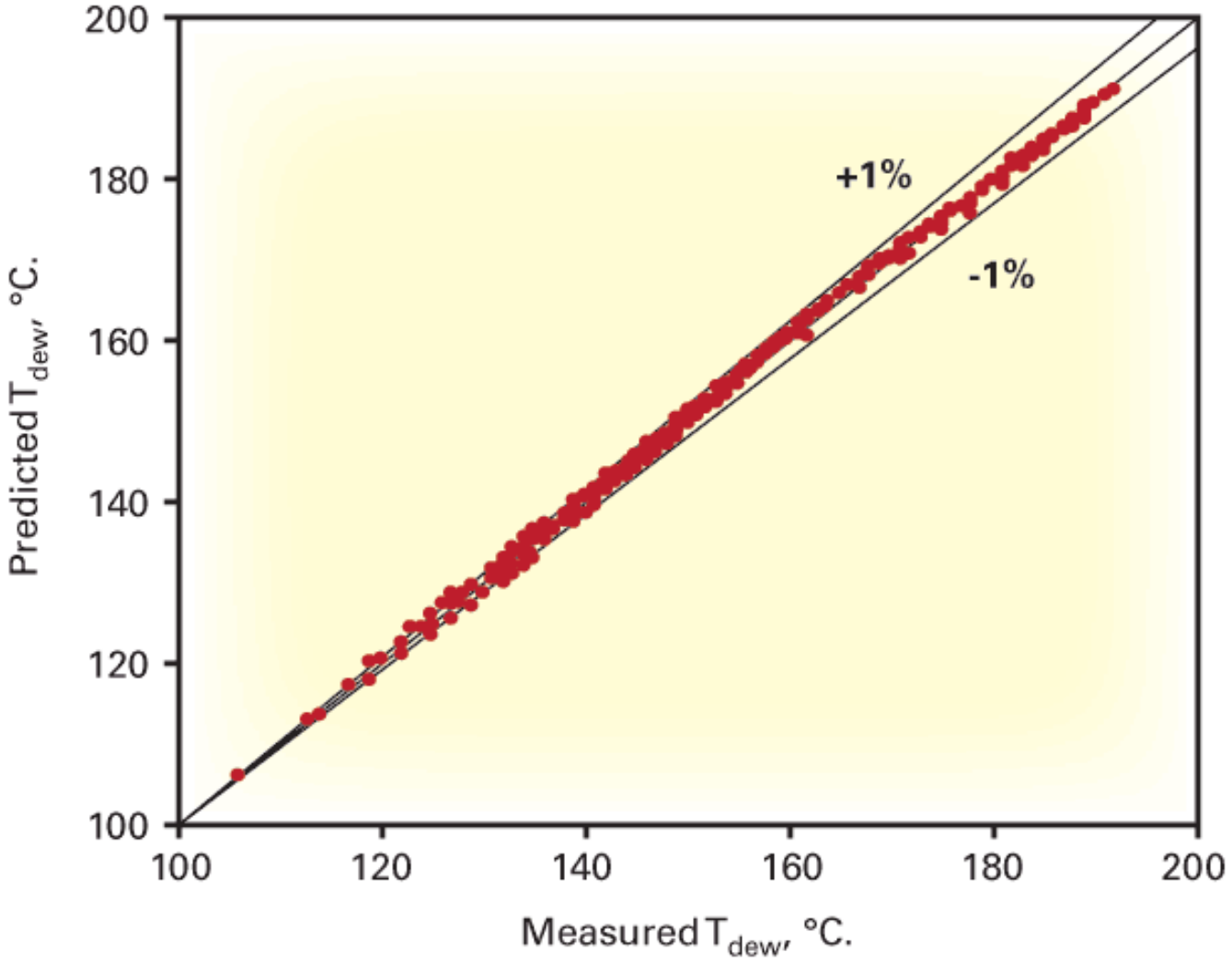
H_2SO_4 formation and dew point (3/3)

- Acid dew points calculated according to Zarenezhad equation:



- Typical dew points in air fired power plants: 95-150°C

PROPOSED CORRELATION VS. MEASURED FLUE-GAS TEMPS. Fig. 5



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SOx ACID DEW POINT CALCULATION

SO2 Concentration (mg/Nm3)

SO2 Concentration (ppm)

SO2 --> SO3 conversion (%)

If you don't know conversion for your specific application set 0.5%

SO3 Concentration (ppm)*

100

H2O Concentration (%vol)*

15

LOG(SO3)

2.000

SOx Acid Dew Point (°C)

161.3

H2SO4 first liquid concentration (%)

84.9

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SOx ACID DEW POINT CALCULATION

SO2 Concentration (mg/Nm3)

SO2 Concentration (ppm)

SO2 --> SO3 conversion (%)

If you don't know conversion for your specific application set 0.5%

SO3 Concentration (ppm)*

100

H2O Concentration (%vol)*

5

LOG(SO3)

2.000

SOx Acid Dew Point (°C)

145.9

H2SO4 first liquid concentration (%)

81.6

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CALCULATOR

Vergelijking calculator met voorgaande vergelijkingen:

- Bij hogere watergehaltes goede overeenkomst met Zarenezhad
- Bij lagere watergehaltes meer richting Okkes

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EQUATIONS

Verhoff and Banchero correlation:

$$\frac{1}{T_{Dew} + 273.15} = 0.002276 - 0.00002943 \ln p_{H2O} - 0.0000858 \ln p_{SO3} + 0.000006260 (\ln p_{SO3})(\ln p_{H2O}) \quad (1)$$

Okkes correlation:

$$T_{Dew} = 203.25 + 27.6 \log p_{H2O} + 10.83 \log p_{SO3} + 1.06 (\log p_{SO3} + 8)^{2.19} \quad (2)$$

New proposed correlation:

$$T_{Dew} = 150 + 11.664 \ln (p_{SO3}) + 8.1328 \ln (p_{H2O}) - 0.383226 \ln (p_{SO3}) \ln (p_{H2O}) \quad (3)$$

Modified Verhoff and Banchero correlation:

$$\frac{1}{T_{Dew} + 273.15} = 0.002281 - 0.00003103 \ln p_{H2O} - 0.00008611 \ln p_{SO3} + 0.000006193 (\ln p_{SO3})(\ln p_{H2O}) \quad (4)$$

Modified Okkes correlation:

$$T_{Dew} = 202.96 + 28.32 \log p_{H2O} + 10.81 \log p_{SO3} + 1.14 (\log p_{SO3} + 8.06)^{2.185} \quad (5)$$

$$RMSD = \sqrt{\frac{\sum_{i=1}^{N} [(T_{Dew,calc.})_i - (T_{Dew,exp.})_i]^2}{N}} \quad (6)$$

Nomenclature

T_{Dew}	=	Sulfuric-acid dewpoint temperature, °C.
p_{H2O}	=	Partial pressure of H_2O in the flue gas, mm Hg
p_{SO3}	=	Partial pressure of SO_3 in the flue gas, mm Hg
y_{H2O}	=	Concentration of H_2O in the flue gas, vol %
y_{SO3}	=	Concentration of SO_3 in the flue gas, ppm (vol)
RMSD	=	Root mean square deviation
i	=	Data point index
N	=	Number of data points

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REFERENTIES

[5] B. ZARENEZHAD: New correlation predicts flue gas sulfuric acid dewpoints. In: Oil & Gas Journal 107 (2009), S. 60–63

[6] F.H. VERHOFF ; J.T. BANCHERO: Predicting dewpoints of flue gases. In: Chemical Engineering Progress 70 (1974), S. 71–72

[7] A. G. OKKES: Get acid dewpoint of flue gas. In: Hydrocarbon Processing 7 (1987), S. 53–55

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Experiences: Choice of filter material (5/5)

- Sampling with quarz wool for dust removal
  - Sampling volume ~ 200l (STP)
  - Sampling before and behind SCR catalyst:

No.	Sampling position	SO_3 in fluegas [mg/m3] (STP)
H	Before catalyst	5.8
I	Before catalyst	4.4
J	Behind catalyst	52.0
K	Behind catalyst	53.3
For comparison (sampling with glass wool)		
B	Before catalyst	0.2

acid mist visible after **1-2 minutes** of sampling, minor variation of concentrations

➡ No saturation behaviour with quarz wool

Dust removal by quarz wool

Dust removal by glass wool

Vragen