GeoPyc® 1365

Envelope Density Analyzer

micromeritics®

Calculations

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(Ver -)

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CALCULATED BLANK COUNTS

Assume that multiple blank data sets are available for a given chamber. Each set is required to have a unique chamber+medium mass. When an analysis using calculated blank counts is started, the blank data set index *j* is found such that $m_j \le m < m_{j+1}$ where *m* is the chamber+medium mass for the sample to be analyzed. An error is signaled if there is no such index.

For each measurement cycle to be done the calculated blank counts is found by linearly interpolating counts in the corresponding cycles of blank sets *j* and *j+1* as a function of chamber+medium mass.

$$n_i = n_{i,j} + \left(n_{i,j+1} - n_{i,j}\right)\frac{m - m_j}{m_{j+1} - m_j}$$

Each set may have a different number of cycles, *N* , but an error is signaled if

$$N > \min(N_j, N_{j+1})$$

CALCULATED VOLUME CALIBRATION

A scale factor can be calculated from the geometry of the chamber.

$$k_V = \Delta V / \Delta x$$

$$= A$$

$$= \pi d^2 / 4$$

We need to divide by 10 to express the scale factor in cm ^{3}/ mm.

$$k_V = \pi d^2 / 40$$

Force Calibration

The force transducer is calibrated using a spring with known spring constant.

First, the force signal and position counts are recorded at the home position (V_0 at n_0).

Plunger positions at two different measured forces are recorded, n_{low} and n_{high}. The plunger is then moved in 10 equal steps from n_{low} and n_{high}. Position, n_i and force signals V_i are measured at each step.

A least-squares straight-line fit is done through

$$x_i = V_i - V_0$$

$$y_i = k_s k_x (n_i - n_0)$$

where x_i is in volts, and y_i is in newtons. The new force calibration slope is the slope of the line in N/V.

Percent of Sample Volume

The fraction of the volume of the contents of the chamber that is due to the sample is

$$f_s = V_s / (V_s + V_b)$$

where

V_b	=	volume of the chamber contents without sample
V_s	=	volume of the chamber contents with sample

The calibration scale factor divides out so we can write

$$f_s = (n_b - n_s) / (n_0 - n_s)$$

The zero depth position, n_0 , is needed since the total volume is relative to the empty chamber. The percent of sample volume reported is 100% $\overline{f_s}$ where $\overline{f_s}$ is calculated from the average of n_b and n_s over the consolidation cycles.

Percent Porosity

Porosity is determined from envelope density and entered absolute density.

$$P = 100\,\%\left(1 - \rho_e / \rho_a\right)$$

Plunger Position

The plunger is moved by a screw attached to a stepper motor. Distance moved in millimeters is proportional to the number of counts from the stepper motor encoder.

$$x = k_x n$$

$$r_m = 400 \ \text{counts/revolution}$$

The lead screw is 5/16-24 UNF.

$$r_t = 24 \ \text{revolution/in}$$

$$k_x = (r_m r_t)^{-1} \ \text{in/count}$$

$$k_x = 1 / 9600 = \ \text{in/count} \ = 127 / 4800 = \ \text{mm/count}$$

SAMPLE ENVELOPE DENSITY

Envelope volume is the volume of an object that includes small pores and cavities. The GeoPyc reports volume that is not accessible to the Dry Flo medium as envelope volume.

When compressed by the piston, the volume of material in the chamber is $V_e = Ax$ where A is the cross-sectional area of the chamber and x is the plunger position relative to the bottom of the chamber.

Sample volume is found as the difference in volume of the sample and medium and the volume of a blank run.

$$V_e = A((x_b - x_0) - (x_s - x_0))$$

$$= A(x_b - x_s)$$

$$= Ak_x(n_b - n_s)$$

This voids the need to know the position of the bottom of the chamber.

In practice, a scale factor, k_V, determined by volume calibration is used instead of Ak_x.

$$V_e = k_V(n_b - n_s)$$

Envelope density is found from the measured envelope volume and the entered sample mass.

$$\rho_e = m / V_e$$

SPECIFIC PORE VOLUME

Specific pore volume is determined from envelope density and entered absolute density.

$$V_p = \left(1/\rho_e - 1/\rho_a\right)$$

Volume Calibration

Measurement of a reference sample with a known properties allows k_V to be determined.

If the reference volume, V_r, is known the envelope volume equation can be solved for k_V. The average over the measurement cycles is used.

$$k_V = V_r / (\overline{n}_b - \overline{n}_s)$$

This can be written in terms of the average envelope volume from the calibration run.

$$k_V = k_V^* \frac{V_r}{V_e}$$

where k_V^* is the conversion factor used in the run.

If mass, absolute density, and porosity are known, the reference volume can be calculated from the porosity equation.

$$P = 1 - \rho_e / \rho_\alpha$$

$$= \quad 1 - \frac{m}{V_e \rho_\alpha}$$

$$V_r = \frac{m}{\rho_\alpha (1 - P)}$$

Volume error is the difference between the average measured envelope volume and the entered or calculated reference volume.

$$\Delta V = V_e - V_r$$

Zero Depth Position

When finding the plunger position at the bottom of the chamber, the plunger is assumed to be extended by 1/2” in (4800 counts).

$$n_0 = n + 4800$$

Compendium of Variables

k_s	=	spring constant
k_V	=	scale factor for converting plunger position to volume
k_x	=	scale factor for converting plunger position in counts to millimeters
m	=	sample mass
n	=	plunger position in stepper motor counts
n_0	=	plunger counts at the bottom of the chamber
n_b	=	plunger counts without sample
n_s	=	plunger counts with sample
P	=	percent porosity
V_e	=	envelope volume
V_p	=	pore volume
V_r	=	calibration reference volume
x	=	plunger position in millimeters
x_0	=	plunger position at the bottom of the chamber
x_b	=	plunger position without sample
x_s	=	plunger position with sample
ρ_a	=	absolute density
ρ_e	=	envelope density