Thermal Conductivity Measurements - Bond Line Correction

The measurement of thermal conductivity is fairly simple except for all the details. First, it is difficult to measure just the specific test sample material. Second, accurate measurement and fixed value forcing of the flux through the test sample is relatively difficult. Third, the temperature differential across the test sample must be measured with sufficient resolution to get desired accuracy.

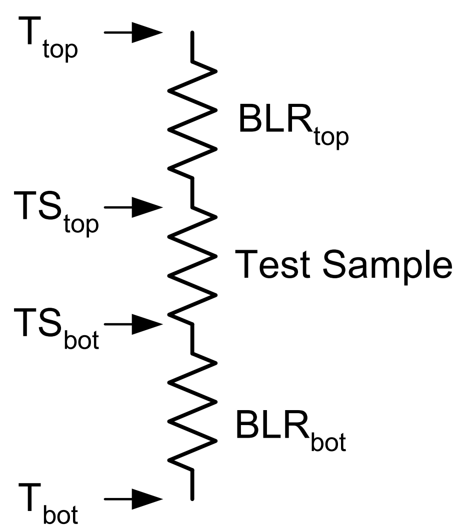

Figure 1

Bond Line Correction

The impact of the contact resistance between the test sample and the measurement apparatus is best described by Figure 1. On each side of the test sample is a Bond Line Resistance (BLR), one on top and one on the bottom. Often the BLR is much poorer in thermal conductivity than the resistance of the Test Sample, thus resulting in direct measurement data values that are not remotely in the range of the actual Test Sample material. If the same material is used for interfacing the Test Sample to the measurement apparatus top and bottom portions, then it is reasonable to assume that BLR_{top} is equal to BLR_{bot}. Otherwise the BLR must be considered to be different on top and bottom.

Using the thermal conductivity equation (1) below, note that for a fixed sample area (A), the thermal conductivity (K_θ) is directly proportional to the sample thickness (L) and inversely proportional to the ratio of the differential temperature (ΔT) across the sample divided by the heat flux (Q) through the sample.

$$K_\theta = \left[\frac{1}{\frac{\Delta T}{Q}}\right] x \frac{L}{A} \qquad (1)$$

For a given material, the K_θ value is constant so plot of $\Delta T/Q$ versus L produces a straight line that should have a positive slope and pass through the origin. However, when measurements are made on a set of same-material test samples having the same areas

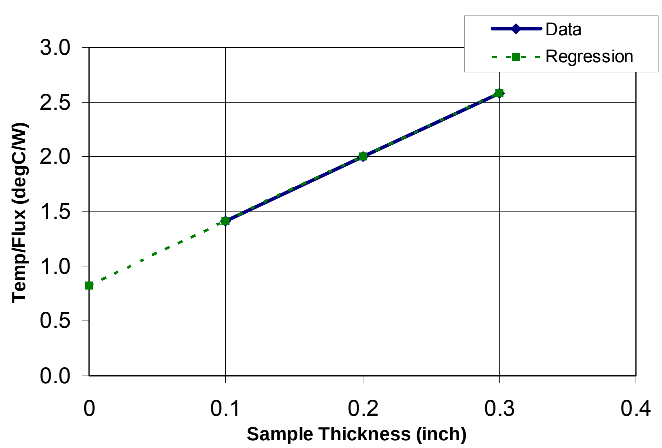

Figure 2

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Thermal Conductivity Measurements - Bond Line Correction (cont'd)

but different thicknesses, a straight line with a positive slope is produced (see Figure 2) but it does not pass through the origin.

The data in Table 1 and Table 2 produced the 'Data" and "Regression" plots shown in Figure 2. The Y-Axis intercept (Y_0) is caused by the presence of BLR_{top} and BLR_{bot}. A simple modification of the equation (1) above produces the equation (2) below that takes care of the BLR presence –

$$K_\theta = \left[\frac{1}{\frac{\Delta T}{Q} - Y_0} \right] x \frac{L}{A} \qquad (2)$$

Sample Thickness	Sample Temp Diff	Measured Thermal Conductivity	Avg Heat Flux	Temp/Flux (Data)	Temp/Flux (Regression)	Corrected Thermal Conductivity	Corrected Thermal Conductivity
0					0.8298		
0.100	5.975	8.376	4.22	1.4151	1.4153	0.3487	**13.727**
0.200	7.705	8.589	3.85	2.0013	2.0008	0.3484	**13.717**
0.300	10.097	9.364	3.90	2.5861	2.5864	0.3486	**13.724**
inch	°C	W/m-K	W	°C/W	°C/W	W/inch-K	**W/m-K**

Table 1

The value of Y_0 is 0.82976 °C/W in this example.

Once Y_0 is determined, this value can be used with equation (2) when testing different thicknesses the same material. If the cross-section area is not same as that used in the BLR determination, the same equation can be used to scale the areas.

It should be noted that the data results used in Table 1 were obtained using the same interface material, the same uniform application of this material, and the same compressive pressure to insure repeatable and meaningful data. The apparatus for making thermal conductivity measurement is commercially available from TEA – please contact the TEA for further information.

Regression Statistics	
Multiple R	0.999999769
R Square	0.999999538
Adjusted R Square	0.999999076
Standard Error	0.000562789
Observations	3

	Coefficients
Intercept	0.829762351
X Variable 1	5.855384173

Table 2

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