KYOTO ELECTRONICS MANUFACTURING CO., LTD.

Application Note

Thermal conductivity measurement of brake pad for Vehicle

Field	:	Machine Metal Pats
Apparatus	:	Quick Thermal Conductivity Meter
Analytical Method	:	Hot Wire Method
Standard	:	
Document No.	:	EAPTM-0001
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1. Scope

The brake pad is a key component of the disk brake system. Two brake pads are positioned between the calipers and the rotors. When stepping the brake pedal to stop the vehicle, brake pads squeeze the brake rotor, thus the pressure and friction are applied to the rotor. As the result, the kinetic energy of rotor is converted to the thermal energy by friction. Both brake pads and rotor are heated by the generated frictional heat. The thermal conductivity property of brake pads is important to keep the maximum performance of brake system.

The Quick Thermal Conductivity Meter makes the quality control of thermal conductivity of brake pads easy. The details are shown as follows.

The Quick Thermal Conductivity Meter has an excellent operability and can be measured easy and rapidly. When starting to measure with holding the probe (Figure 1) to the sample surface of uniform temperature, it will be possible to measure in only 60 seconds.

2. Measurement principle

The probe is composed by the hot wire and the thermocouple put straight. The theoretical equation for the temperature versus time is as follows;

$$T_2 - T_1 = \frac{q}{4\pi\lambda}\ln(t_2 - t_1)$$

where λ is the thermal conductivity, q is quantity of heat, T_1 and T_2 are temperature at the instants of time t_1 and t_2. This means that the temperature has a liner characteristic as a function of the logarithmic of the time. (Figure 2)

The slope of this linear line will be large due to the temperature rise quickly for the low thermal conductivity sample. On the other hand, the slope will be small due to the temperature rise slow for the high thermal conductivity.

Therefore the thermal conductivity of sample can be obtained from the slope of the temperature versus the logarithmic of the time.

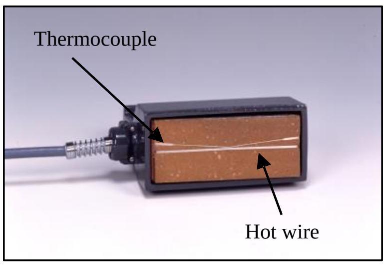

Figure 1. Probe

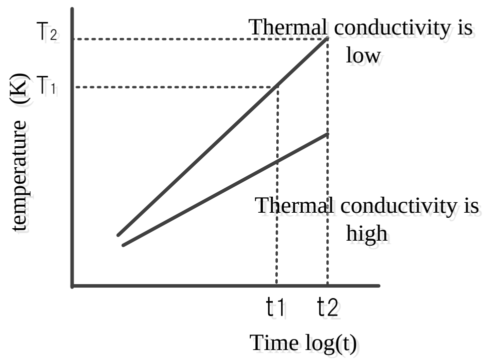

Figure 2. log(t)vsT(℃) graph

3. Precautions

1) The conductivity of sample is confirmed by using multimeter before starting measurement to select the probe.
2) The standard probe (PD-11) is for non-conductive sample and the insulated moisture-proof probe (PD-13) is for conductive sample.
3) The heater current value is decided that the temperature rise during measurement may become within 5 ˚C to 20 ˚C. Then the decided heater current value is set from [Heater Screen] of the main unit and the appropriate heater current value has to be selected depending on the sample.
4) Make sure the sample size is 100mm(width) x 50mm(length) x 20mm(thickness) or more. The surface of contact side with probe makes flat to avoid the air gap between sample and probe.
5) When you measure the thin sample, please follow one of procedures as shown below;
   ① Pile up the sample or measure it on the material which has equivalent thermal conductivity.
   ② Measure with the optional Software for thin Sheet Measurement.

   ※ For checking the effect of the worktable, if there is more than 5% deviation for the measurement values between on the foamed polyethylene and the alumi cooling plate, the thin material procedure has to be used.
6) The temperature of sample is made almost equal with the environment temperature before starting measurement.

4. Apparatus

Main unit : Quick Thermal Conductivity Meter
Probe : Standard probe [PD-11] (*1)
Insulated moisture-proof probe [PD-13] (*2)

*1; Standard parts of device
*2; Use for the conductive, adhesive or wet sample

The insulated moisture-proof probe is covered with the polyimide film to protect the heater line, the thermocouple, and the base material of the probe. The sample that is possible to measure with the standard probe can be measured with the insulated moisture-proof probe too.

5. Measurement condition

The samples are both conductive and non-conductive.
The conductive sample is measured with the insulated moisture-proof probe, and the non-conductive sample is measured with both of the standard probe and the insulated moisture-proof probe.

－Measurement condition－

Sample	Probe	Heater current value I^2
Non- conductive	Standard probe	4.000
Conductive	Insulated moisture-proof probe	4.000

The heater current value is set that the temperature rise during measurement may become within 5˚C to 20˚C. The temperature rise is small when the heater current is small, so that the error and relative standard deviation become large.
Moreover, the temperature rise becomes 25˚C or more when the heater current is excessive, so that the measurement is stopped.

6. Result

The measurement result of the thermal conductivity of brake pad for vehicle is shown as below.
The measurement is performed three times, and a mean value, standard deviation and relative standard deviation are applied.

－Ambient condition－

Temperature	23 ˚C

－Measurement result－

The measurement result of thermal conductivity of brake pad

Sample	Non-conductive		Conductive
Probe	Standard probe	Insulated moisture-proof probe	Insulated moisture-proof probe
Measurement value(W/mK)	0.8430	0.8407	1.3466
	0.8332	0.8662	1.3479
	0.8579	0.8416	1.3473
Mean value (W/mK)	0.845	0.850	1.35
Standard deviation (W/mK)	0.0124	0.0145	0.0007
Relative standard deviation(%)	1.5	1.7	0.1

7. Summary

The measurements of both the conductive and the non-conductive sample show an excellent result within 3% of the relative standard deviation.
The result can be confirmed there is no difference when the non-conductive sample is measured with the standard probe and the insulated moisture-proof probe.
Therefore, the insulated moisture-proof probe is recommended for the sample that has both conductive and non-conductive.

8. Reference

None

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