4. Example of Data Recording and Processing

Note: the data below are for reference purpose only, not the criteria for apparatus performance.

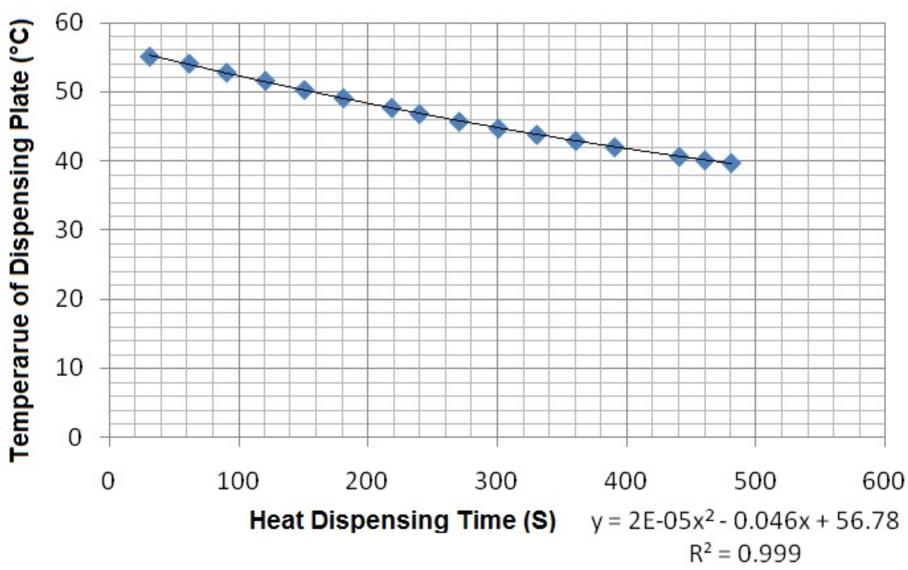
4.1 Heat conductive coefficient measurement of poor conductor

At the steady state, record T_1=78.4 °C, T_2=42.8 °C. Heat the heat dispensing plate to exceed 50 °C. Separate the heating plate and the heat dispensing plate and turn off the PID control while recording the temperature of the heat dispensing plate at regular intervals until the heat dispensing plate is cooled down.

t (s)	31.1	61.6	90.6	120.6	150.8	180.9	218.3	239.7	270.5
T (°C)	55.1	54.1	52.8	51.6	50.3	49.1	47.7	46.8	45.7

300.8	330.6	360.7	390.8	440.8	460.6	481.0
44.7	43.8	42.9	42.0	40.6	40.1	39.7

Plot the above data and do binomial polynomial curve fitting (R^2 = 0.999), indicating that the temperature distribution of the heat dispensing plate is a binomial distribution. At temperature T_2, the corresponding cooling rate $\frac{dT}{dt}\Big|_{T=T_2}$ is the slope at T_2, we have $\frac{dT}{dt}\Big|_{T=T_2}$ = -0.03105.



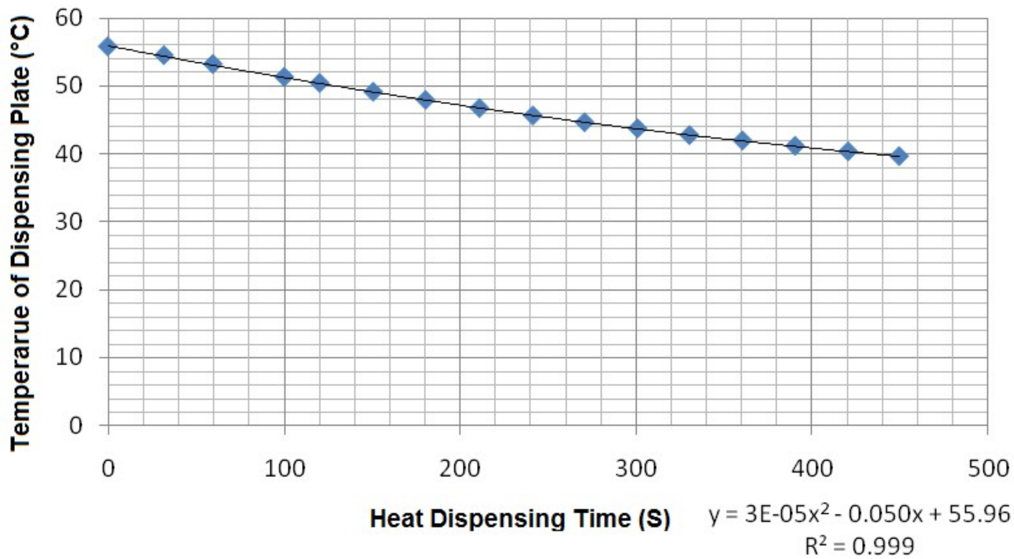
Use formula (5) to calculate the heat conductive coefficient of rubber, we get λ=0.28 W/(m•K), indicating that rubber material is a poor conductor.

4.2 Heat conductive coefficient measurement of air

At the steady state, record T_1=77.6 °C, T_2=45.0 °C. Heat the heat dispensing plate to exceed 55 °C. Separate the heating plate and the heat dispensing plate and turn off the PID control while recording the temperature of the heat dispensing plate at regular intervals until the heat dispensing plate is cooled down.

t (s)	0	31.9	59.7	100.2	120.3	150.8	180.5	211.1	241.5	300.9	330.4	360.5	390.4	420.5	449.5
T (°C)	55.8	54.5	53.2	51.3	50.4	49.1	47.9	46.7	45.6	43.7	42.7	41.9	41.1	40.3	39.6

Plot the above data and do binomial polynomial curve fitting (R^2 = 0.999), indicating that the temperature distribution of the heat dispensing plate is a binomial distribution. At temperature T_2, the corresponding cooling rate $\left.\frac{dT}{dt}\right|_{T=T_2}$ is the slope at T_2, we have $\left.\frac{dT}{dt}\right|_{T=T_2}$ = -0.03424. The thickness of air layer is 1.0 mm.



Use formula (5) to calculate the heat conductive coefficient of air, we get λ=0.0225 W/(m•K). In comparison, the heat conductive coefficient of air at room temperature 300 K with a density of 1.1774 kg/m^3 is 0.02624 W/ (m•K).

4.3 Heat conductive coefficient measurement of metal

The distance between the upper and lower holes of the aluminum cylinder for mounting temperature sensors is 80 mm. The initial temperature difference between upper and lower plates is ΔT_0=-0.2 ℃. Record temperature every 15 seconds after starting heating until temperature difference obviously gets smaller as shown in the table below.

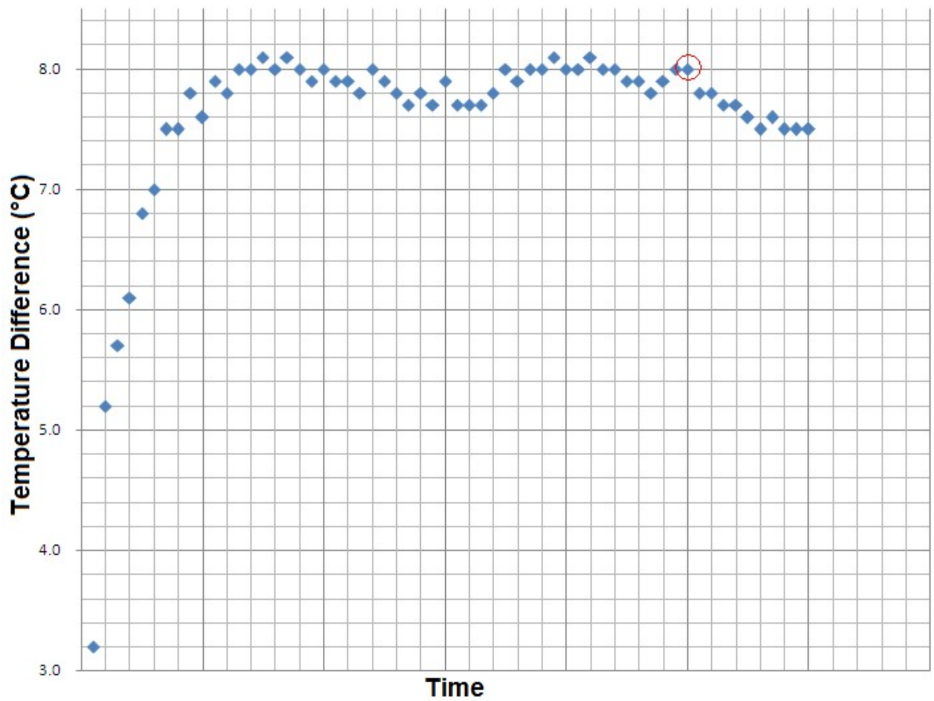
Upper hole T (℃)	32.3	35.8	37.1	38	39.5	40.1	41.2	41.5	42.2	42.2	42.8	43	43.8	44
Lower hole T (℃)	29.3	30.8	31.6	32.1	32.9	33.3	33.9	34.2	34.6	34.8	35.1	35.4	36	36.2
Actual ΔT (℃)	3.2	5.2	5.7	6.1	6.8	7	7.5	7.5	7.8	7.6	7.9	7.8	8	8

44.5	44.5	44.8	45	45.2	45.6	45.8	46	46.1	45.6	46.6	46.7	46.8	47.1	47.2	47.8

36.6	36.7	36.9	37.2	37.5	37.8	38.1	38.3	38.5	37.8	38.9	39.1	39.3	39.5	39.7	40.1
8.1	8	8.1	8	7.9	8	7.9	7.9	7.8	8	7.9	7.8	7.7	7.8	7.7	7.9

47.7	47.8	48	48.2	48.6	48.8	49.1	49.3	49.7	49.8	50	50.2	50.3	50.5	50.6	50.7
40.2	40.3	40.5	40.6	40.8	41.1	41.3	41.5	41.8	42	42.2	42.3	42.5	42.7	42.9	43
7.7	7.7	7.7	7.8	8	7.9	8	8	8.1	8	8	8.1	8	8	7.9	7.9

50.8	50.9	51.2	51.5	51.6	51.8	51.9	52.1	52.4	52.5	52.6	52.6	52.6	52.7
43.2	43.2	43.4	43.7	44	44.2	44.4	44.6	45	45.2	45.2	45.3	45.3	45.4
7.8	7.9	8	8	7.8	7.8	7.7	7.7	7.6	7.5	7.6	7.5	7.5	7.5



We can see form the above graph that the temperature difference obviously becomes smaller after the red circled point from which we can consider the aluminum cylinder sample has reached a steady-state with data highlighted in yellow color in the table. Select one point for calculation, such as T_1=50.5 ℃，T_2=42.7℃.

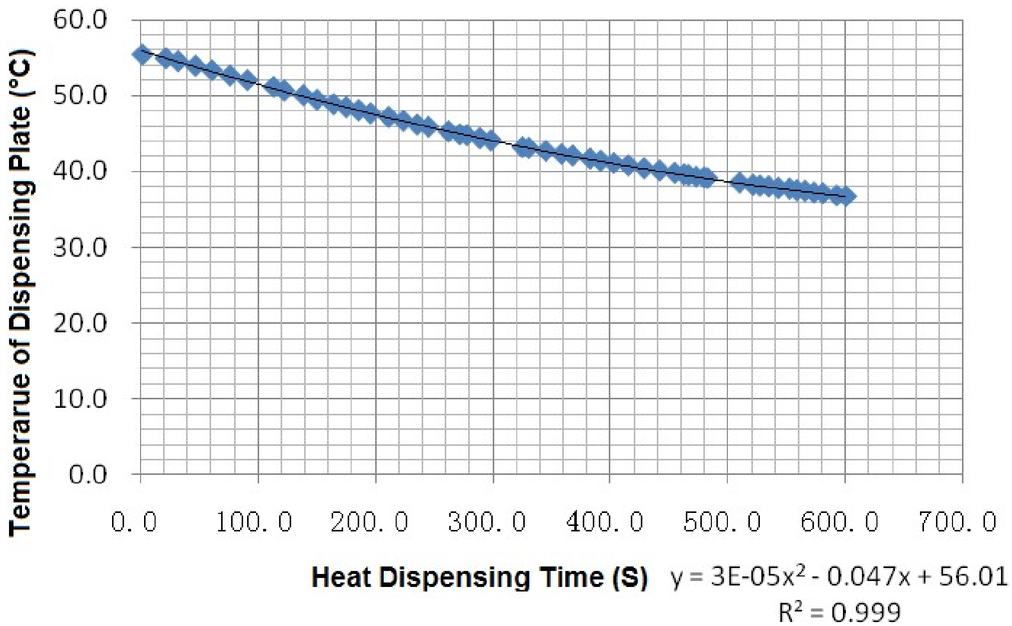
Remove the sample cylinder, heat the heat dispensing plate to a higher temperature and then let it cool in air while recording the temperature of the heat dispensing plate with time as shown below:

t (s)	1.1	20.9	31.4	46.1	60.2	75.6	90.3	112.6	121.7	138.1	149.6	163.6
T (°C)	55.5	55	54.6	54	53.4	52.7	52.1	51.2	50.7	50.1	49.5	48.9

174.4	185	195.2	210.5	223.2	234.9	244.4	261.5	271.2	277.1	288.2	297.8	324.5	329.8
48.5	48.1	47.7	47.2	46.7	46.2	45.9	45.3	44.9	44.8	44.4	44.1	43.2	43.1

344.4	357.8	367.2	382	391	402.2	414.6	428	441.2	454.1	462	465.9	472.4	479.1
42.7	42.3	42.1	41.7	41.4	41.1	40.8	40.4	40.1	39.8	39.6	39.5	39.3	39.2

482	509.4	520.7	526.8	534	542.3	551.9	558	565.1	572.5	580.2	592.1	600
39.1	38.5	38.2	38.1	38	37.8	37.7	37.5	37.4	37.2	37.1	36.8	36.7



Plot the above data and do binomial polynomial curve fitting (R^2 = 0.999), indicating that the temperature distribution of the heat dispensing plate is a binomial distribution. At temperature T_2, the corresponding cooling rate $\frac{dT}{dt}\Big|_{T=T_2}$ is the slope at T_2, we have $\frac{dT}{dt}\Big|_{T=T_2}$ = -0.02984.

Use formula (8) to calculate the heat conductive coefficient of aluminum cylinder sample, we get λ=170.9 W/(m•K). In comparison, the recognized heat conductive coefficient of aluminum alloy 6061-T6 is 167 W/(m•K), therefore, the experimental error is 2.3%.

Note: factors of ambient temperature, thermal grease thickness and steady-state determination have a significant impact on the experimental result.

4.4 Specific heat capacity measurement of metal

Temperature sampling range of the heat dispensing plate is from 84 ℃ to 80 ℃.

Cooling time of the copper plate (s): 148.3; 156.3; 155.8; 150.7; 153.6

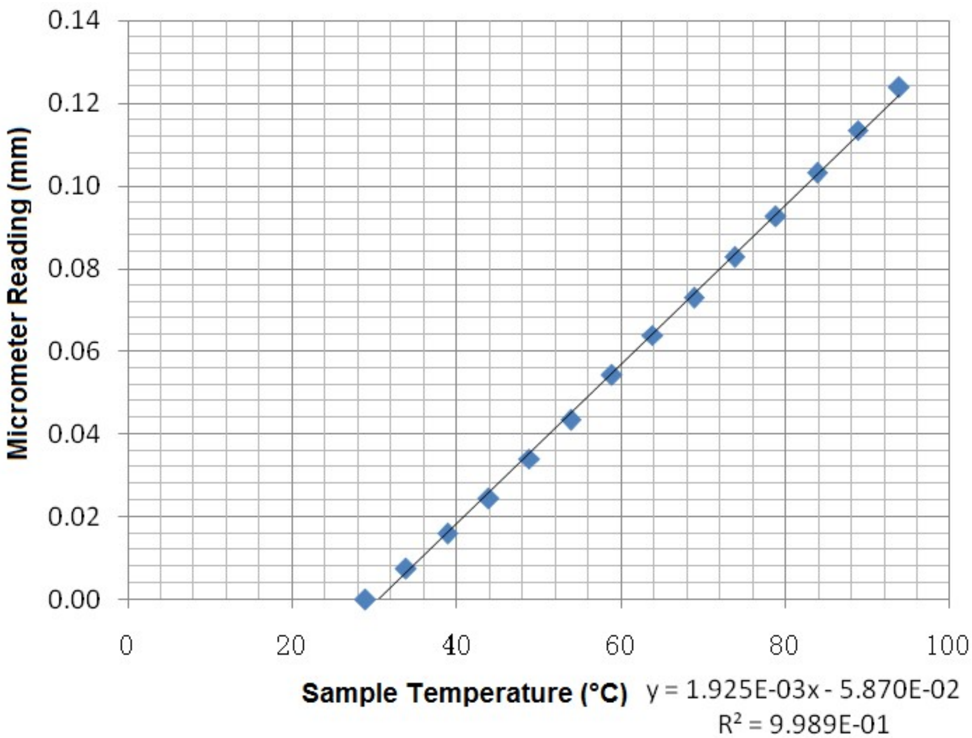
Cooling time of the aluminum plate (s): 133.1; 129.6; 137.5; 130.6; 135.1

Take C_1=0.39×10^3 J/(kg•°C) (copper) and substitute all parameters into formula (16), we get C_2=1.057×10^3 J/(kg•°C) (aluminum). In comparison, the recognized value of the specific heat capacity of aluminum is 0.896×10^3 J/(kg•°C).

4.5 Heat expansion coefficient measurement of metal

Data is recorded and shown in the table below:

T (°C)	28.9	33.9	38.9	43.9	48.9	53.9	58.9	63.9	68.9	73.9
Δl (×10^{-6} m)	0	7.5	16	24.5	34.1	43.5	54.2	64	73	82.8
T (°C)	78.9	83.9	88.9	93.9	…					
Δl (×10^{-6} m)	92.6	103.2	113.5	123.8	…					



Using formula (19), we get α=16.04×10^{-6} (°C^{-1}). In comparison, the recognized value of the linear expansion coefficient of copper is 17.7×10^{-6} (°C^{-1}).