People's Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

University of Mohamed Boudiaf-M'Sila

جامعة محمد بوضياف - المسيلة
Université Mohamed Boudiaf - M'sila

FACULTY OF SCIENCES **FIELD: Material sciences**

DEPARTEMENT DE PHYSIQUE **FILIERE : Physique**

OPTION : physique énergétique

3rd year license energy physics

TP: STUDY OF THERMAL CONDUCTION

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Mohamed Boudiaf University – M'sila

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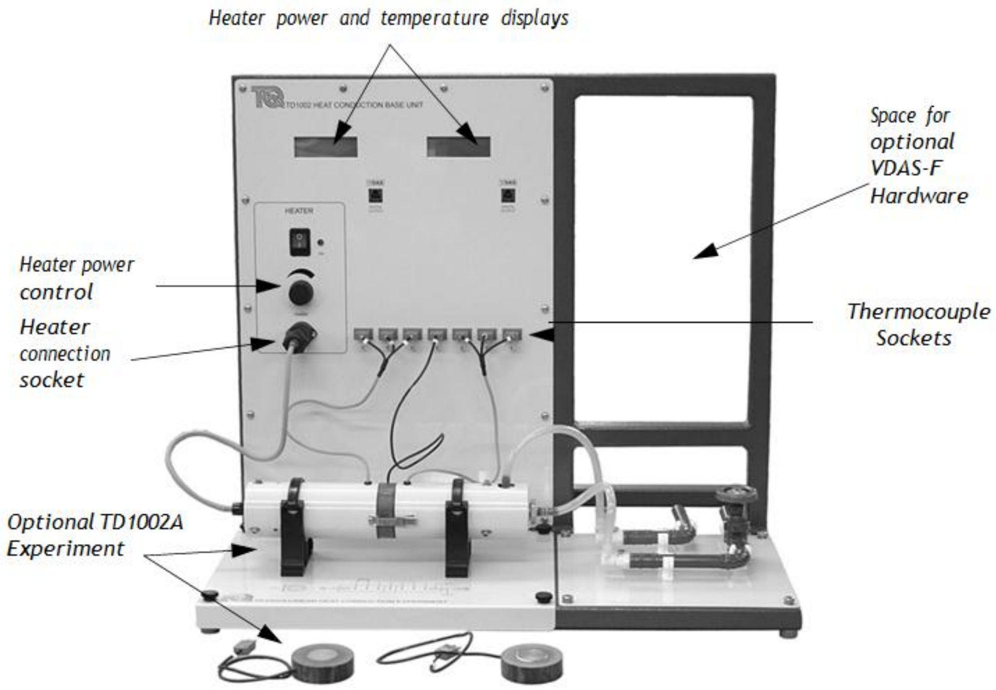

Figure 1. The linear heat conduction experiment (TD1002A)

This experimental unit shows how heat is conducted along a solid brass bar of uniform circular section. It has an electric radiator at one end to generate thermal energy (the "heat source") and a small chamber at the other end ("the heat sink"). The cold water supply from the base unit circulates through the heat sink to remove thermal energy. A thermal switch next to the radiator works with the base unit to cut off power to the radiator if it becomes too hot.

Seven thermocouples equidistant along the bar measure the temperature gradient between the heat source and the heat sink. The bar includes an interchangeable center section to allow you to adapt different metals (included) and study how they affect the temperature gradient along the bar. Insulation surrounds the bar to reduce heat loss through radiation and convection, giving you more accurate results to compare with theory.

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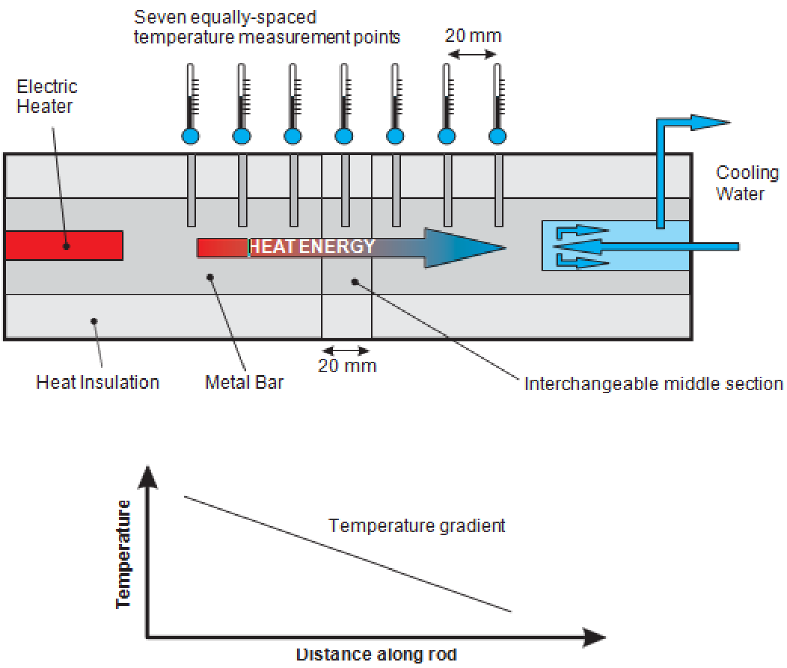

Figure 2. The operation of the linear heat conduction experiment (TD1002A)

Installation

1. Place the base unit on your workbench. Check if your experimental unit needs a cold water supply.

2. If the experiment unit requires a cold water supply, connect the base unit's cold water inlet and drain fittings to your cold water supply and drain.

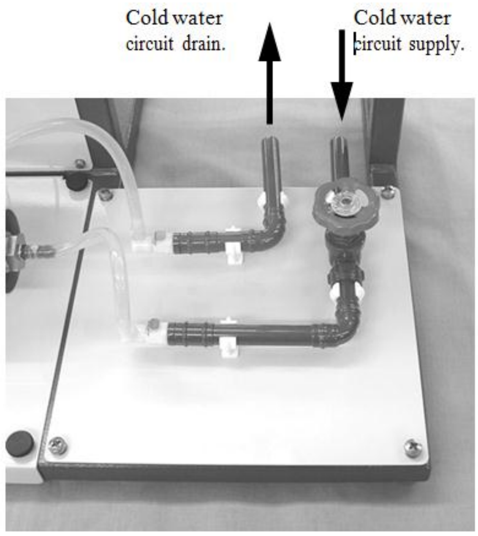

Figure 3. Cold water supply

Thermal conductivity (k) of materials:

Thermal conductivity, noted λ (lambda) expressed in W/m.K, is what will make it possible to measure the quantity of energy, of heat which is propagated by conduction: in one second, on a 1m² surface of a wall measuring 1m thickness, for a temperature difference of 1°C between the two faces of the material. Table 1 shows the thermal conductivity of some common materials. Note that metals (electrical conductors) have higher conductivity than most other materials (electrical insulators) at the same temperature. This suggests a link between electrical and thermal conductivity.

Material (at 298 K)(24.85°C)		**Typical Thermal Conductivity (*k*) W.m^{-1}K^{-1}**
Metals	Aluminium (pure)	205 to 237
	Aluminium (grade 6082)	170
	Brass (type CZ121)	123
	Brass (63% copper)	125
	Brass (70% copper)	109 to 121
	Copper (pure)	353 to 386
	Copper (type C101)	388
	Mild Steel	50
	Stainless Steel	16
Gas	Air	0.026
	Carbon Dioxide	0.0146
	Hydrogen	0.172
Others	Asbestos	0.28
	Castor Oil	0.18
	Glass	0.8
	Water	0.6
	Wood (softwood to hardwood)	0.07 to 0.2

Table 1. Thermal conductivity of selected materials at room temperature

Conduction in permanent mode:

Heat transfer by axial, unidirectional conduction is reacted by Fourier's law which states that: $q = -\lambda . A . dT/dx$

With: DT/dx: is the temperature gradient along x (°C/m).

λ: is the thermal conductivity of the body (W/m°C). A: is the heat exchange surface. - The quantity of heat given up or exchanged between two bodies varies depending on the nature and type of the wall. For a cylindrical wall the expression is as follows :

$$q = T_1 – T_2 / Ln(r 2/r 1)/2.\pi.k.L$$

For a spherical wall:

$$q = T_1 – T_{n+1} / \Sigma (1/r i – 1//r i+1)/4.\pi.ki$$

OPERATING MODE

Select a low position on the power switch (approximately 10 W), wait for steady state then read the 09 temperatures on the digital temperature display. This procedure must be repeated for two other powers of 15 and 20 W. The temperatures during the three tests must not exceed 100°C, risk of damage to the equipment. The results obtained are (The distance between two points is 2 cm) :

Material 1

	Q(W)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
A										
B										
C										

Material 2

	Q(W)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
A										
B										
C										

Material 3

	Q(W)	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
A										
B										
C										

Using the results for each power setting, plot graphs of temperature versus distance along the bar, relative to the first thermocouple (T_1). You should be able to draw a good best-fit line through your results. If the average temperature value (T4) is not close to the line, you have not installed the middle part correctly. - Calculate the thermal gradient of the line for reference. Use the two furthest readings T_1 and T_9, the given distance between them, the heater power and the area of the bar with equation 5 to calculate the thermal conductivity of the metal bar. Compare it with the typical value given in Table 1. Can you explain the cause of the errors, if any? What do you notice about the slope of the graphs for each heating power setting? - Repeat procedure 1, but use the different materials available in the middle section.