Heat pipes were applied to the research project of NASA in the beginning.

As the information technology era has been started, more and more diverse and advanced 3C products, which heat density gets increasing.

To make electronic products smaller, the efficient cooling component—heat pipes are now applied to a lot of consumer electronics. It is also a key cooling unit in electronic heat transfer field.

Long Win's Educational Facilities for Thermal & Flow

LW–9354 Heat Pipe Thermal Performance Measurement

Experimental items

Heat transfer rate of heat pipes

Thermal resistance of heat pipes

Maximum heat transfer of heat pipes

Features

Commercial heat pipe samples

Cross-sections for different wick structure

Attitude-adjustable for thermal resistance test

With an instruction board

About Heat Pipes

Heat pipes are generally called the **super conductor of heat**.
The transfer function results from man-made wick structure.
There are several advantages to use heat pipes for heat dissipation.

1.**Light**: It is made by hollow metal, and quite lighter than metals with the same volume.
2.**Durable**: There are no movable parts inside heat pipes, and no wearing problem.
3.**Easy to operate**: It is a closed-loop structure, and no need to adding working fluid.

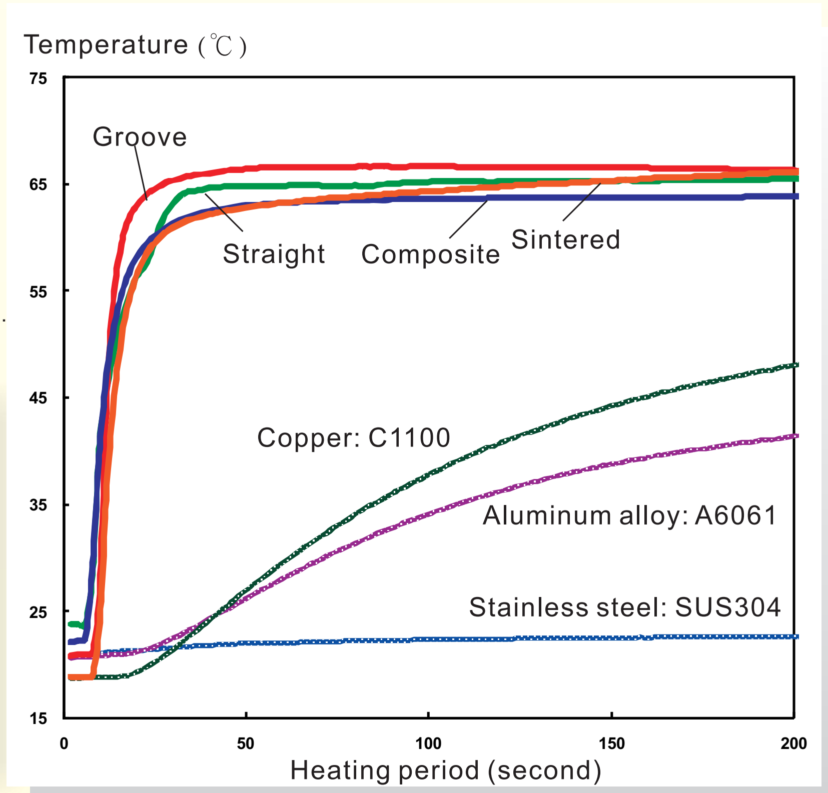
This apparatus can handle heat pipe's **heat transfer rate**, **thermal resistance**, and **maximum heat transfer tests**. Students can study through operating tests of heat pipes, initiate the foundation of knowledge, and be inspired to keep motivation on this field.

(I) Heat Transfer Rate Testing

Four heat pipes with different wick structure:
1.**Straight**: with smooth inner wall.
2.**Groove**: with grooves on the inner wall.
3.**Sintered**: sintered by copper powder on the inner wall.
4.**Composite**: both grooves and copper nets are covered on the inner wall.

Three metal rods:
1.Copper: **C1100**
2.Aluminum alloy: **A6061**
3.Stainless steel: **SUS304**

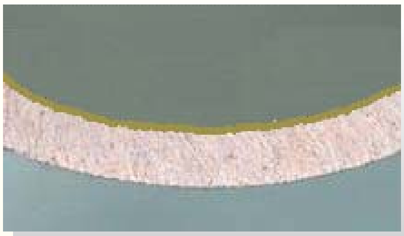
Length of heat pipes: 197 mm
Outer diameter of heat pipes: 6 mm
Immersion length in the hot water bath: 60 mm
Thermo couple position:
100 mm higher than bath surface.

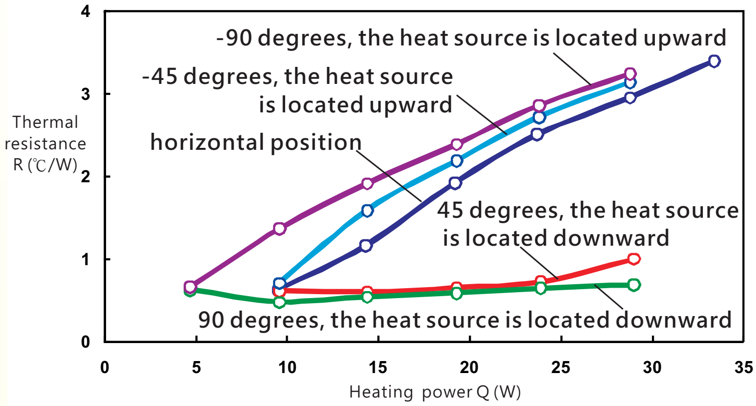


1. No matter what kind of **heat pipe** is, it reaches **balance in 30 seconds**.
2. For **C1100** and **A6061** material rods,
   the **heat transfers to the cool side after 20 seconds**.
   During 300 seconds, the temperature of cool side is **continuously increased**.
3. For **SUS304**, there is **no significant increase of temperature**.
4. The **temperature gradient** of solid material is proportional to
   thermal conductivity coefficient.

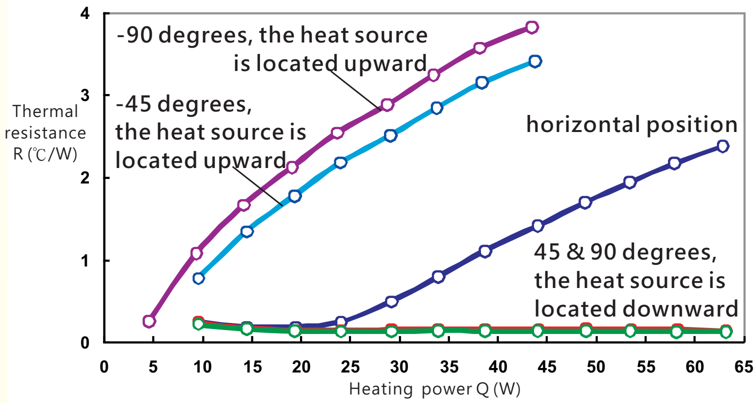
(II) Thermal Resistance Testing

Straight structure

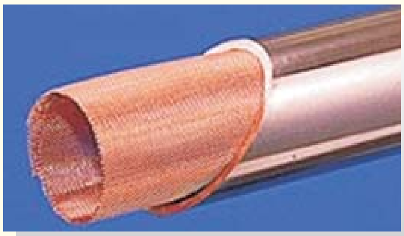


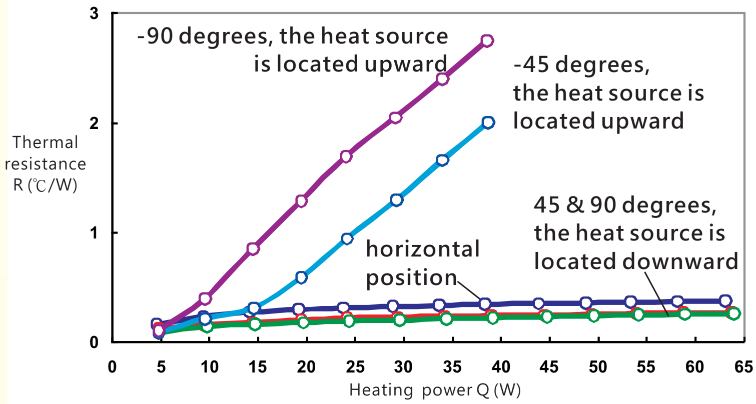


Groove structure

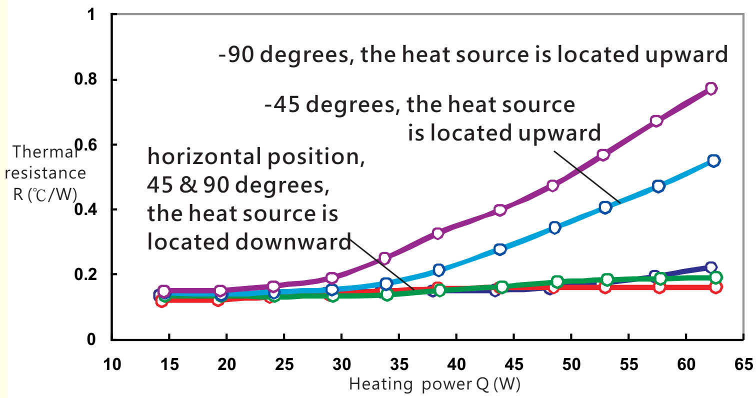


Composite structure





Sintered structure



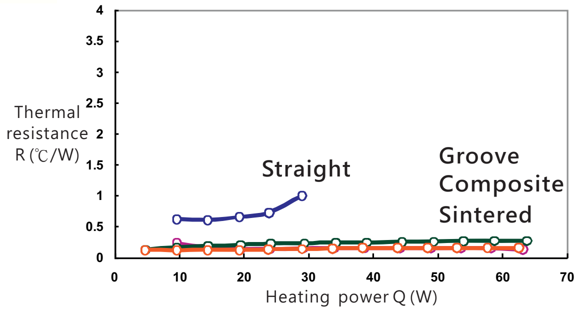
At this part, we maintain working fluid, vacancy, length, diameter, and working temperature in constant, and then compare the effect of wick structure, attitude, and heating power on heat pipes. The conclusion lists below:

1. At vertical attitude, heat pipes have lower thermal resistance when the heating source is located downward. The resistance value has several times lower than the upward condition.
2. At horizontal attitude, thermal resistance values are ordered from low to high: Sintered ≒ Composite < Groove < Straight

(III) Thermal Performance at different attitudes

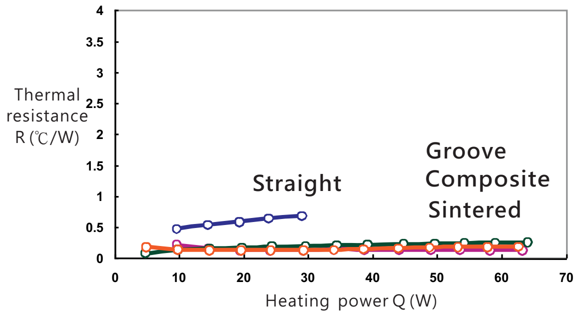
<u>45 degrees, heat source is located downward.</u>

Heat exchange capability:
Sintered≒Composite
≒Groove＞Straight



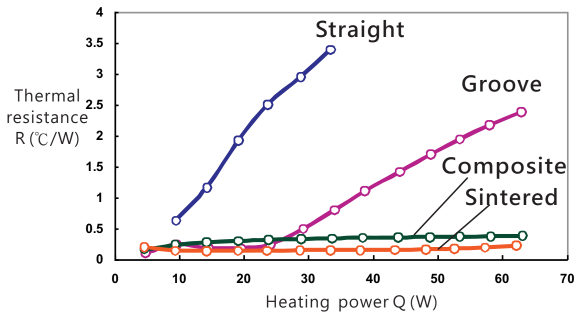
<u>90 degrees, heat source is located downward.</u>

Heat exchange capability:
Sintered≒Composite
≒Groove＞Straight



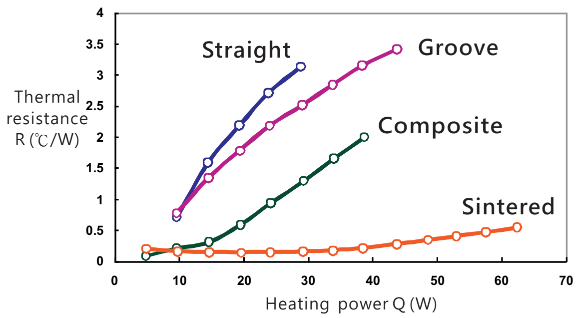
<u>Horizontal position</u>

Heat exchange capability:
Sintered≒Composite
＞Groove＞Straight



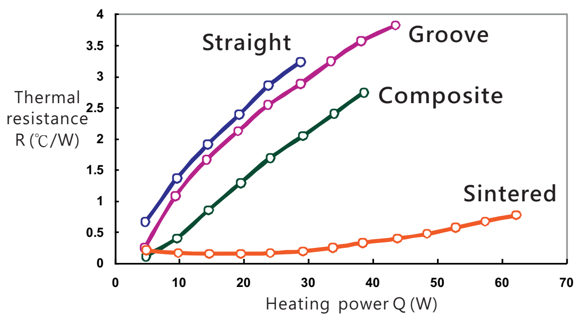
<u>-45 degrees, heat source is located upward</u>

Heat exchange capability:
Sintered＞Composite
＞Groove＞Straight



<u>-90 degrees, heat source is located upward</u>

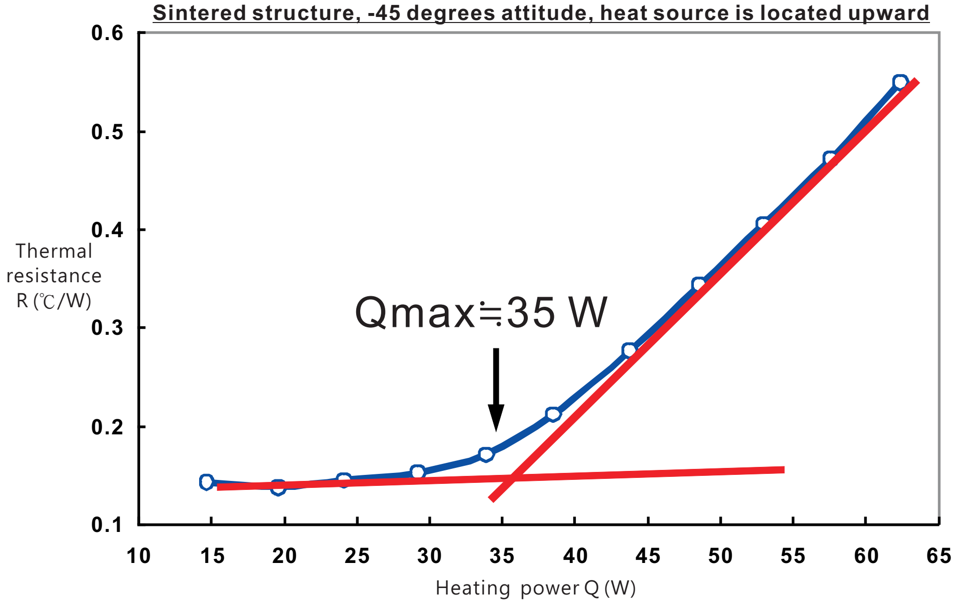
Heat exchange capability:
Sintered＞Composite
＞Groove＞Straight



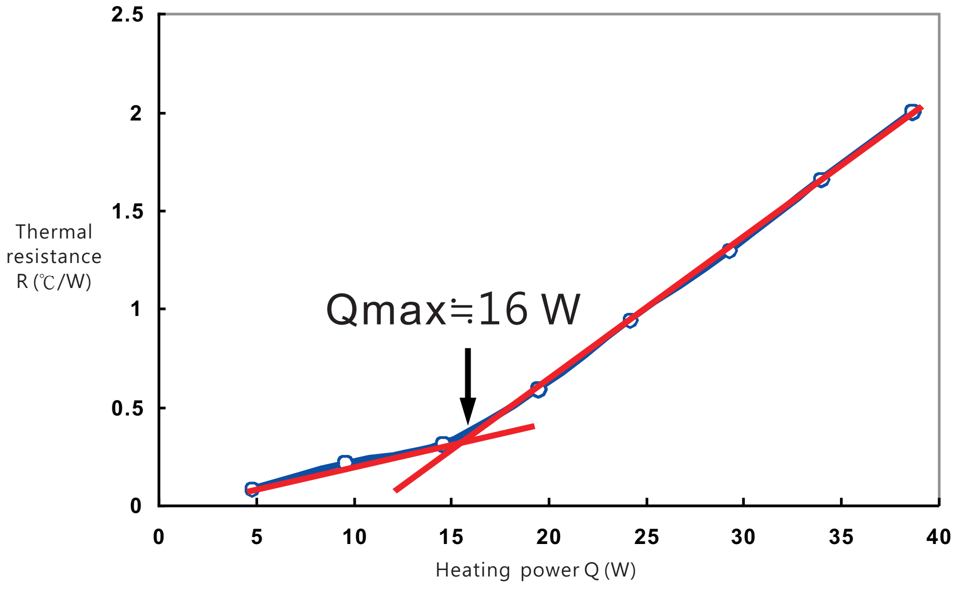
While comparing performance of different wick structures at different attitudes, **sintered structure**'s thermal resistance is lower than 1 ℃/W in each condition.
We can say it is the wick structure **with best heat exchange capability**.
While **heat source** is located **upward**, the **ability of pulling working fluid** can be compared.
The order from **the best to worst** is <u>sintered</u>, <u>composite</u>, <u>groove</u>, and <u>straight</u> heat pipes.
At this condition, **wick attraction** is the most significant factor to affect **heat exchange**.

(IV) Maximum Heat Transfer Testing

Sintered structure, -45 degrees attitude, heat source is located upward



Composite structure, -45 degrees attitude, heat source is located upward



When the working fluid cannot be vaporized and recycled at a high input power, the thermal resistance will be increased suddenly.

The situation is called "**drying out**".

If we extrapolate two segments with different slopes, there is a cross point.

The corresponding power value is called the **maximum heat transfer(Qmax)**.

Specifications

1. Commercial heat pipes are verified by their wick structures.

1.1 Straight structure

1.2 Groove structure

1.3 Sintered structure

1.4 Composite structure

2. Experiments

2.1 Heat transfer rate test:

Comparison with different heat pipes and metal materials and under different working temperatures

2.2 Thermal resistance test under different attitudes

2.3 Maximum heat transfer performance test

3. Testing platform

3.1 Controllable heating power platform:

To calculate the quantity of heat and average temperature of heating module

3.2 Controllable cooling temperature platform:

To establish temperature difference for heat transfer measurement

3.3 Heating module:

a.Power supply: DC30V, 3 Amp

b.Th measurement and digital display

3.4 Cooling module:

a. Water temperature control: ambient +5 ~ 50℃

b. Tc measurement and digital display

c. Water flow rate modulation unit

3.5 Constant press load mechanism on heating and cooling module

3.6 Heat transfer rate test: constant temp. water tank and timer

3.7 Attitudes: +45°, +90°, 0°, -45°, -90°

4.Overall dimension: 0.6 (D) × 1.2 (L) × 1.6 (H) m (Ref.)

4.1 With an instruction board

5.Power source: AC220V, 5 Amp, 50/60 Hz, single phase

Educational Facilities for Thermal & Flow

(I) Basic Fluid Mechanics Experiments

LW-9341 Venturi Tube-Bernoulli's Equation Apparatus

LW-9342 Pipe Line Pressure Loss Apparatus

LW-9346 Air Flow Rate Measurement Apparatus

- Orifice, Venturi tube, Nozzle and Rotameter

LW-9350 Hele-Shaw Flow Visualization Apparatus

LW-9357 Orifice and Nozzle's Cd Measurement Apparatus

(II) Basic Heat Transfer Experiments

LW-9344 Cooler Module's Forced Convection Heat Transfer Apparatus

LW-9345 Fan PQ Performance Apparatus

LW-9354 Heat Pipe Thermal Performance Measurement Apparatus

LW-9394 The Principle and Calibration Apparatus of Temperature Sensors

(III) Water Tunnels

LW-9174 Horizontal Water Tunnel

LW-3457 Water Tunnel

(IV) Wind Tunnels

LW-6200 Open-loop Subsonic Wind Tunnel (Cross area of test section: 200 × 200 mm)

LW-9300 Open-loop Subsonic Wind Tunnel (Cross area of test section: 300 × 300 mm)

LW-3840 Wind Tunnel for Wind Generator Testing

(V) Related Accessories

LW-9390 IR Imaging Camera

LW-9117 Laser Sheet Generator

LW-9356 NACA Airfoil Model

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