Heat Pipes

Lecture directed to third class students

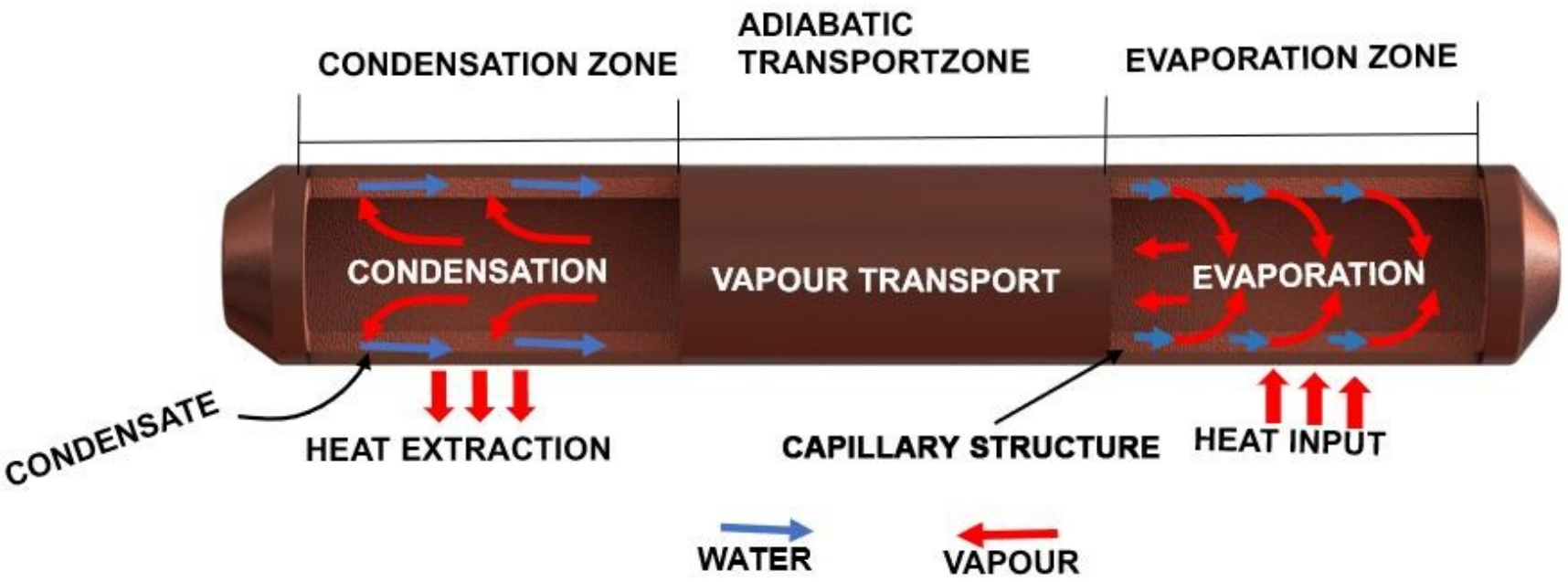
Mech. Dept. – HVAC Branch

Spring semester 2021

Definition of a heat pipe

Heat pipe is a long slim pipe closed at its two ends. It is filled with certain quantity of a working fluid. The working fluid transfers heat between the two ends of the pipe via evaporation in one side and condensation on the other. An adiabatic region is sometimes located in the middle separating the two pipe ends. The internal surface is sometimes covered or lined with a wick or fine porous material.

Schematic Cut of a Typical Heat Pipe



Operation Principle

When one of heat pipe ends is made in direct contact with a heat source the liquid in that side absorbs heat and evaporates. The vapor fills all the pipe cavity. When the other side is cooled the vapor condenses in that side releasing the absorbed heat. The condensate returns to the heat source side by gravity assisted by the capillarity effect of the wick material, and sometime against gravity.

Advantages of Heat Pipes

1) Allows efficient heat transfer between a source and a sink.
2) Assures constant temperatures at hot (source) and cold (sink) sides due to the change of phase.
3) Suitable for small scale or limited space applications like the cooling of electronic components.
4) Can operate against gravity due to the act of the wick material.
5) Flexible in applications of various geometries and sizes.
6) Can be installed as a single part or several separate and parallel pipes.

Disadvantages of Heat Pipes

1) Difficulty to fabricate especially the small sizes.
2) They require perfect evacuation before charging the working fluid.
3) Effective wick material is sometimes difficult to manufacture.
4) The use of metal of high thermal conductivity and the appropriate conjugated working fluid further increases the heat pipe cost.

Classification and Types of Heat Pipes

Heat pipes can be classified according to the existence of the wick into two categories:

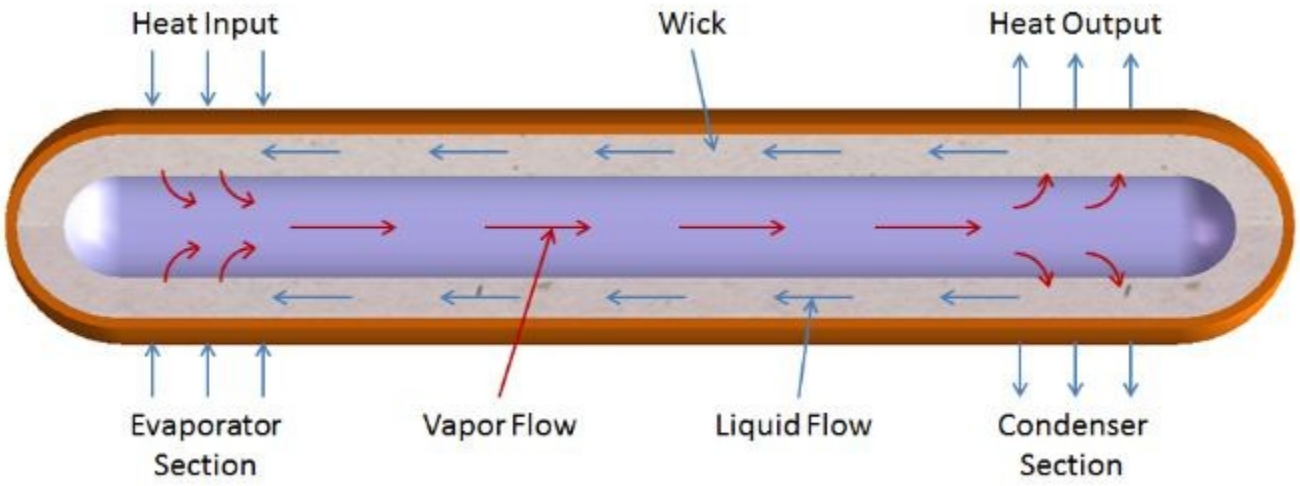
1) Conventional heat pipes with wick structure: which can operate against gravity.
2) Wickless heat pipes (closed thermosyphons): in which the operation depends on gravity. They are sometimes called *gravity assisted heat pipes*. The evaporator is this category must always be located at the lowest level and the condenser at the top.

Classification and Types of Heat Pipes

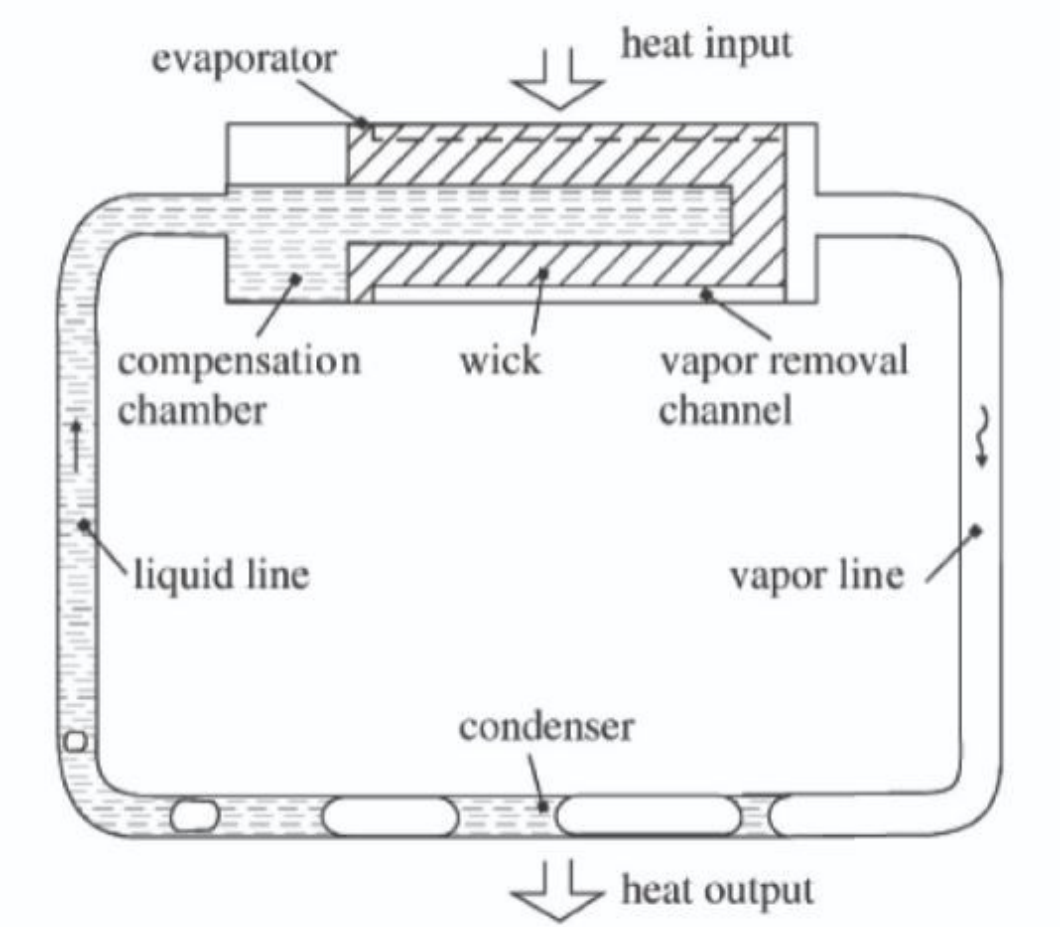
Heat pipes can also be divided into three categories:

1) Straight Type: which is simply a long slim pipe. The condensate in this type returns to the evaporator through the same vapor line.
2) Loop Type: In this category the two ends of the heat pipe are connected together forming a closed cycle or loop. The condensate returns through a separate line called the *downcomer*. The vapor line is called the *upriser*. Wick material is seldom used with loop types.
3) Pulsating or Oscillating Heat Pipes: In this modern type the evaporation and condensation occur concurrently forming a flow of liquid slugs and vapor plugs.

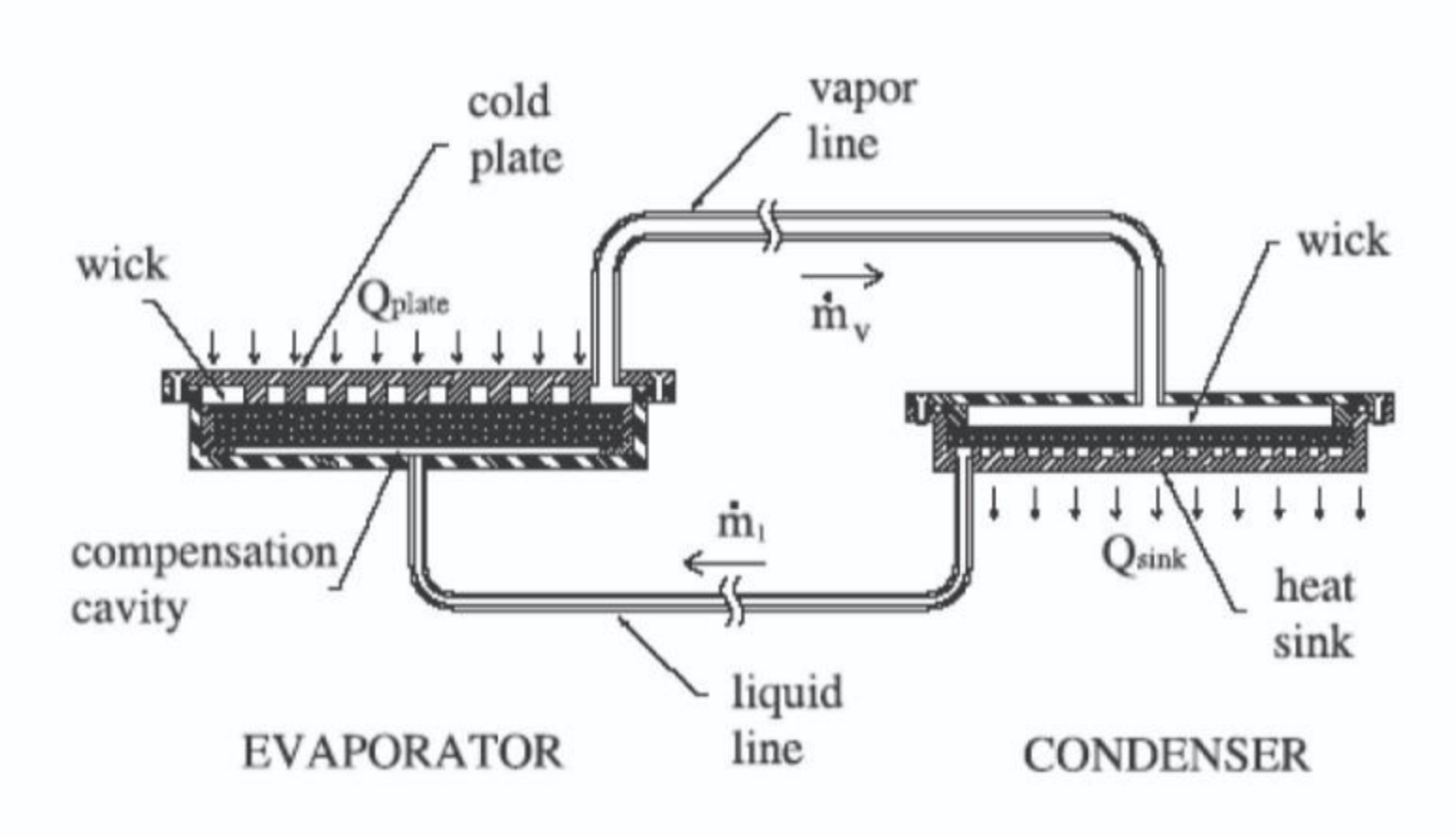
Schematic View of a Straight Heat Pipe



Schematic View (1) of a Loop Heat Pipe



Schematic View (2) of a Loop Heat Pipe



Schematic View of a Pulsating Heat Pipe