# HEAT TRANSFER

In thermal science, heat transfer is the passage of thermal energy from a hot to a cold body. When a physical body, e.g. an object or fluid, is at a different temperature than its surroundings or another body, transfer of thermal energy, also known as heat transfer, occurs in such a way that the body and the surroundings reachthermal equilibrium. Heat transfer always occurs from a hot body to a cold one, a result of the second law of thermodynamics. Transfer of thermal energy occurs mainly
through conduction, convection or radiation. Heat transfer can never be stopped; it can only be slowed down.

Heat transfer is of particular interest to engineers, who attempt to understand and control the flow of heat through the use of thermal insulation, heat exchangers, and other devices. Heat transfer is typically taught as an undergraduate subject in both chemical and mechanical engineering curriculums.

Terminology

Conduction - transfer of heat by electron diffusion or phonon vibrations (see below)

Convection - transfer of heat by conduction and bulk mass transfer (see below)

Heat - the internal kinetic, vibrational energy that all materials contain (except at absolute zero)

Radiation - emission of heat by electromagnetic radiation (see below).

Conduction

Main article: Heat conduction

Conduction is the transfer of thermal energy through free electron diffusion or phonon vibration, without a flow of the material medium. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from atom to atom. Conduction occurs mainly in solids, where atoms are in constant contact. In liquids and gases, the particles are further apart, giving a lower chance of particles colliding and passing on thermal energy.

Metals are the best conductors of thermal energy. This is due to the way that metals are chemically bonded:metallic bonds (as opposed to covalent or ionic bonds) have free-moving electrons and form a crystalline structure, greatly aiding in the transfer of thermal energy.

Fluids (liquids and gasses) are not typically good conductors. This is due to the large distance between atoms in a gas: fewer collisions between atoms means less conduction. As density decreases so does conduction. Conduction does not occur at all in a perfect vacuum.

To quantify the ease with which a particular medium conducts, engineers employ the conduction coefficient, also known as the conductivity constant or thermal conductivity, k. The main article on thermal conductivity defines k as "the quantity of heat, Q, transmitted in time t through a thickness L, in a direction normal to a surface of area A, due to a temperature difference ΔT [...]." Thermal conductivity is a materialproperty that is primarily dependent on the medium's phase, temperature, density, and molecular bonding.

## Convection

Main article: Convection

Convection is a combination of conduction and the transfer of thermal energy by circulation or movement of the hot particles to cooler areas in a material medium. This movement occurs from or to a fluid or within a fluid. In solids, molecules keep their relative position to such an extent that bulk movement or flow is inhibited.

Convection occurs in two forms: natural and forced convection.

In natural convection, fluid surrounding a heat source receives heat, becomes less dense and rises. The surrounding, cooler fluid then moves to replace it. This cooler fluid is then heated and the process continues, forming a convection current. The primary driving forces for natural convection are buoyancy and gravity.

Forced convection, by contrast, occurs when pumps, fans or other means are used to propel the fluid and create an artificially induced convection current. In many heat transfer systems, both natural and forced convection contribute significantly to the rate of heat transfer, and the effect of each may be found using thesuperposition principle.

To total the amount of convection between two objects, engineers employ the convection coefficient, h. Unlike the conduction coefficient, the convection coefficient is not a material property. The convection coefficient is based on the geometry, temperature, velocity, and other factors of the system in which convection occurs. Therefore, the convection coefficient must be derived or found experimentally for every system analyzed.

## Radiation

Main article: Thermal radiation

Radiation is transfer of heat through electromagnetic radiation in the heat spectrum. Hot or cold, all objects radiate heat—unless they are at absolute zero, which is unattainable. No medium is necessary for radiation to occur; radiation works even in and through a perfect vacuum. A prime example of this is heat from the Sun, necessary for life on earth, which travels through the vacuum of space before warming the earth.

"Shiny" materials typically reflect radiant heat, just as they reflect visible light; dark materials typically absorb heat, just as they absorb visible light. In actuality, light is another a form of electromagnetic radiation with a shorter wavelength (and therefore a higher frequency) than heat radiation. The difference between visible light and radiant heat is small: they are simply different "colors" of electromagnetic radiation.

Insulation and radiant barriers

Main article: Insulation

Thermal insulators are materials specifically designed to reduce the flow of heat by limiting conduction, convection, or both. Radiant barriers are materials which reflect radiation and therefore reduce the flow of heat from radiation sources. Good insulators are not necessarily good radiant barriers, and vice versa. Metal, for instance, is an excellent reflector and poor insulator.

The effectiveness of an insulator is indicated by its R- (resistance) value. The R-value of a material is theinverse of the conduction coefficient (k) multiplied by the thickness (d) of the insulator. The units of resistance value are in SI units: ($K \cdot m^2/W$)

$$R = \frac{d}{k}$$

Rigid fiberglass, a common insulation material, has an R-value of 4 per inch, while poured concrete, a poor insulator, has an R-value of 0.08 per inch.[1]

The effectiveness of a radiant barrier is indicated by its reflectivity, which is the fraction of radiation reflected. A material with a high reflectivity has a low emissivity, and vice versa (reflectivity = 1 - emissivity). An ideal radiant barrier would have a reflectivity of 1 and would therefore reflect 100% of incoming radiation.

Heat exchangers

Main article: Heat exchanger

A Heat exchanger is a device built for efficient heat transfer from one fluid to another, whether the fluids are separated by a solid wall so that they never mix, or the fluids are directly contacted. Heat exchangers are widely used in refrigeration, air conditioning, space heating, power production, and chemical processing. One common example of a heat exchanger is the radiator in a car, in which the hot radiator fluid is cooled by the flow of air over the radiator surface.

Common types of heat exchangers include parallel flow, counter flow, cross flow, shell and tube, and plate heat exchangers.

Heat transfer in education

Heat transfer is typically studied as part of a general chemical engineering or mechanical engineeringcurriculum. Typically, thermodynamics is a prerequisite to undertaking a course in heat transfer, as the laws of thermodynamics are essential in understanding the mechanism of heat transfer. Other courses related to heat transfer include energy conversion, thermofluids and mass transfer.

Heat transfer methodologies are used in the following disciplines, among others:

Automotive engineering

HVAC

Insulation

Power plant engineering

Source : http://engineering.wikia.com/wiki/Heat_transfer