The First Law of Thermodynamics (closed systems)

The First Law of Thermodynamics states that for any system there exists a property (called energy) that is conserved and may be transferred **in** to or **out** of the system by heat or work interactions.

It follows that if heat (Q) and/or work (W) is transferred **in** to a closed system its energy level will increase by the amount of work done and/or heat transferred.

As we have just seen in the previous section, heat is transferred in to or out of a system by means of a temperature difference between the system and its surroundings.

For heat transfer **IN**: $T_{surroundings} > T_{system}$

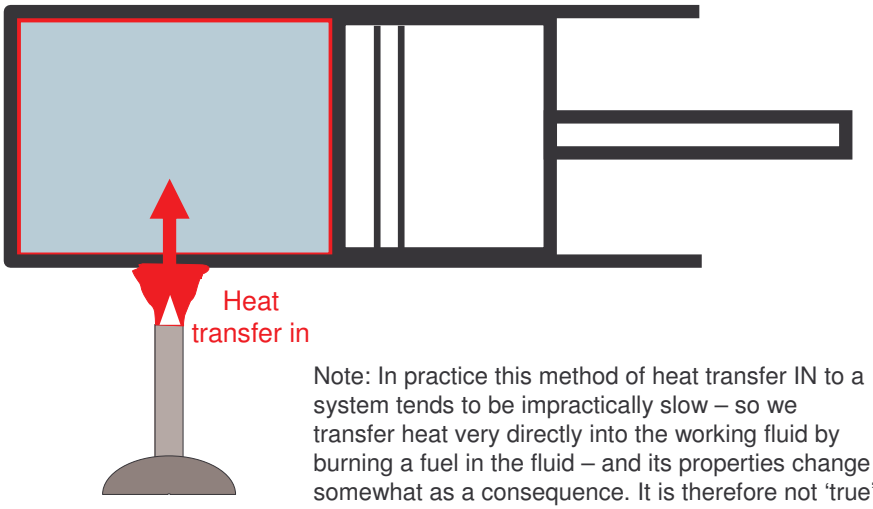
For heat transfer **OUT**: $T_{surroundings} < T_{system}$

The 'surroundings' may be 'hot' gas, or 'cold' liquid, or an evaporating liquid or ??

The 'system' may contain 'cool' gas, or 'warm' liquid, or a condensing vapour or ??

If the temperature difference between system and surroundings is infinitesimally small the heat transfer is **reversible.** (and infinitely slow!)

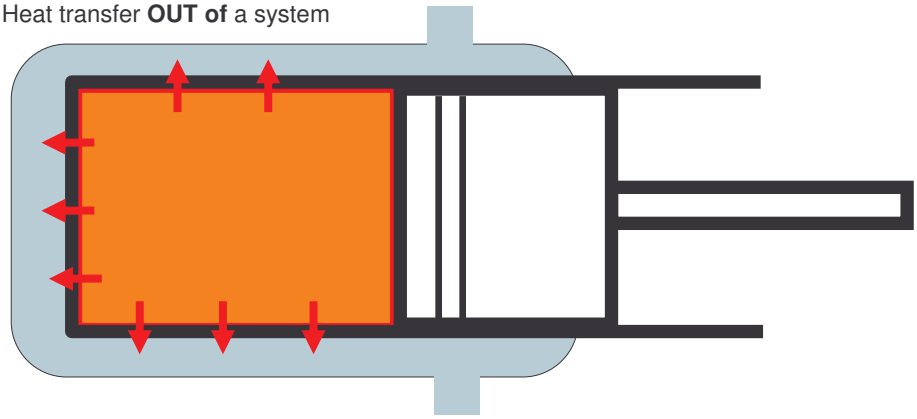
Heat transfer **IN** to a system



Note: In practice this method of heat transfer IN to a system tends to be impractically slow – so we transfer heat very directly into the working fluid by burning a fuel in the fluid – and its properties change somewhat as a consequence. It is therefore not 'true' heat transfer (although we often treat it as such).

The closed system's properties will change as a result of the energy transfer – e.g. increasing temperature and/or pressure

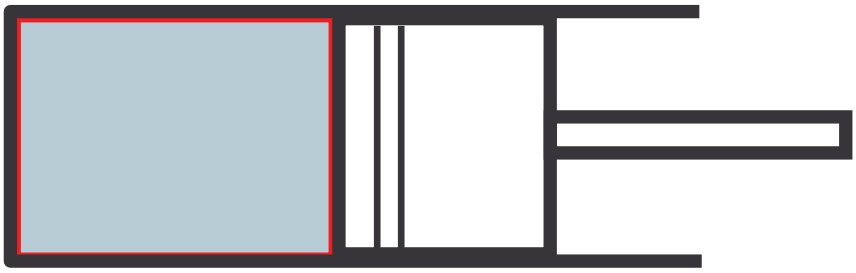
Heat transfer **OUT of** a system



Note: In practice this method of heat transfer OUT of a system tends also to be impractically slow – so we don't even try – we just throw the hot fluid away and replace it with fresh fluid. Some heat transfer is required, however, to ensure that the cylinder material doesn't deform or melt!

The closed system's properties will change as a result of the energy transfer – e.g. decreasing temperature and/or pressure

Work transfer **IN** to a system



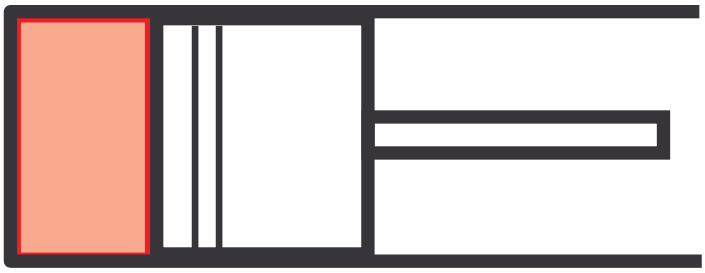
Work transfer in to a system is by means of a 'force' difference, and is typically transmitted by a piston rod, con rod, drive shaft or by some mechanical device.

It typically causes a **compression** process to occur. In practice this process can occur very rapidly and high rates of energy transfer can be achieved.

If the force difference between system and surroundings is infinitesimally small and there is no leakage or friction the work transfer is **reversible.**

The closed system's properties will change as a result of the energy transfer – e.g. increasing temperature and/or pressure

Work transfer **OUT of** a system



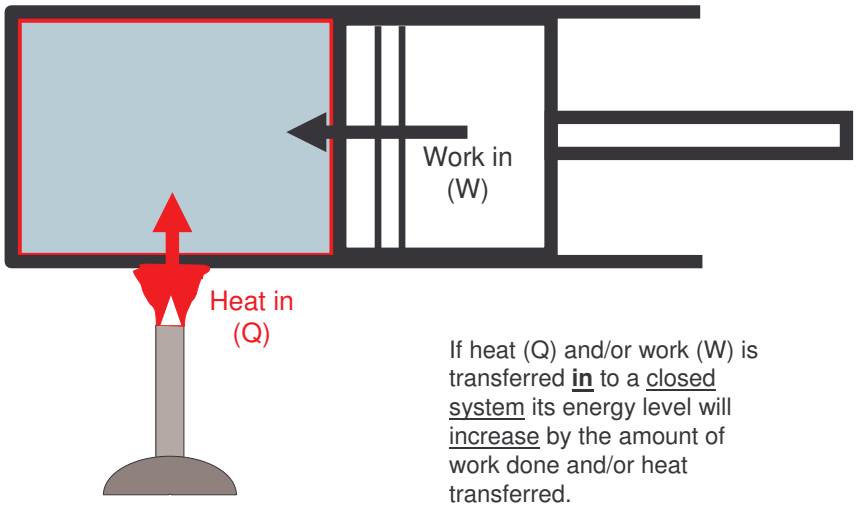
Work transfer out of a system is by means of a 'force' difference, and is also typically transmitted by a piston rod, con rod, drive shaft or by some mechanical device.

It typically causes an **expansion** process to occur. In practice this process can occur very rapidly and high rates of energy transfer can be achieved.

If the force difference between system and surroundings is infinitesimally small and there is no leakage or friction the work transfer is **reversible.**

The closed system's properties will change as a result of the energy transfer – e.g. decreasing temperature and/or pressure

Work and Heat transfer **IN** to a system



If heat (Q) and/or work (W) is transferred **in** to a closed system its energy level will increase by the amount of work done and/or heat transferred.

If we designate the system property ‘energy’ by symbol U then:

$$Q + W = \Delta U$$

This is known as the **non-flow energy equation** (NFEE)(closed system).

Note that work and heat transfer in to a system is defined as positive.
It follows that work and heat transfer out of a system is negative.

Caution: in older text books work transfer out of a system was defined as positive, which means the non-flow energy equation is written as $Q - W = \Delta U$