system could be a heated steel billet which is formed into different shapes. The steel billet may first be heated to very high temperatures. Then at that temperature, it may be rolled into a sheet. It may then be cooled gradually or rapidly by dropping into a water or oil bath. Finally it may be deformed further at the lower temperature. All these processes are performed on the fixed initial mass of the billet even though the shape of the boundary is being changed and energy is being supplied and removed across the boundaries.

On the other hand, a **control volume** is a region of space with a clearly defined boundary. The boundary may be real or imaginary. The boundary may be fixed or changing with time in a known manner. Mass and energy is allowed to cross the boundary of the control volume. An example of a control volume could be a lake with streams of water feeding it. If we consider the quantity of water, there is input through a few streams. Other streams may be taking water out of the lake. There could be loss of water due to evaporation or seepage into the ground. Or there could also be water added to the lake due to rain. If we imagine a boundary around the lake, we can identify the region inside it as a control volume.

So, why do we have these two definitions? Why not choose only one and stick with it? The first definition — the system — allows us to easily keep track of how much energy is being moved around. However, in many practical applications, it's quite difficult to identify systems since mass also moves from place to place. The control volume, on the other hand, is slightly more difficult to analyze. But we can more easily identify control volumes around us.

The basic principles of analysis for both systems and control volumes is the same. It's just that we have to keep track of the quantities much more carefully in each of them.



# 4 Properties, State and Equilibrium

Since our eventual goal is to extract energy from various kinds of systems, we need to keep track of what is happening to it. In order to describe the system we first look at its properties.

We know that any system can have properties such as colour, smell, etc. So a system can have very many properties. However, we are generally interested only in the properties which describe the system. For example, if we need to describe the possible effect of a ball hitting a person, we might be interested in its mass, hardness, speed and position. We would not be interested in its colour.

The properties of a thermodynamic system are broadly classified as **extensive** which change according to the mass of the system (such as energy, momentum, etc) or **intensive** which do not change with the amount of mass of the system (such as temperature).

Two properties are said to be **independent** if one can be varied without changing the other. Two properties which are independent for a system for a certain range of the property variation may become dependent in another range. This will become clear with examples which we will look at later.

The **state** of a system is its condition. It is assumed that the state of a system can be completely described by a finite number of properties. If any of the properties