viscosity than that added at the beginning. The combination of a two roll and five roll refiner system is frequently able to produce a thinner chocolate than a single five roll system, because the mass being refined has a lower fat content and so more fat can be added later in the process.

The emulsifier used, whether it is lecithin, YN or polyglycerol polyricinoleate (PGPR, see Chapter 11) should also be added towards the end of the conching process. Some authors (Ley, 1994) believe that high temperatures are detrimental to the effectiveness of lecithin and that, when conching at high temperatures, additions should only be made when the chocolate has been cooled. Lecithin is also very effective in reducing chocolate viscosity, being approximately ten times as efficient as cocoa butter. Consequently, additions of it into the conche have to be made very accurately. This is often helped by adding it as a mixture with cocoa butter, so that small weighing errors have less effect. Recently, however, metering pumps have become more accurate and suppliers have produced lecithin in a more liquid form, facilitating direct pumping into the conche.

Not only must the fat and emulsifiers be present in the chocolate, they must also coat the sugar and other solid particles uniformly. The efficiency of this coating action depends upon the mixing action of the conche.

10.2.3 Degree of mixing

In order to coat the particles with fat, the conche must move the particles relative to one another within the liquid fat. There are two different types of mixing (Windhab, 1995; see Figure 10.2):

1 Shear mixing, where the chocolate is between two surfaces moving relatively to one another;
2 Elongational mixing, in which the material is squeezed through or spread over a surface.

Failure to mix the chocolate satisfactorily may not only result in a chocolate which is relatively thick for its fat content, but can also produce an unstable viscosity. This can be the cause of chocolate thickening in storage tanks and giving viscosity readings which change as the chocolate is sheared by the viscometer during the measuring cycle.

10.2.3.1 Shear mixing

In conching this takes place between a moving rotor and the outside walls of the machine. The intensity of the mixing can be quantified by a factor known as the shear rate. In Figure 10.2a, the two surfaces are moving at a relative velocity of $v_1 + v_2$ and they are separated by a distance h. The shear rate is then defined by:

$$\text{shear rate} = (v_1 + v_2)/h \tag{10.1}$$

This rate is in the units 1/time and is normally expressed in s^{-1}.

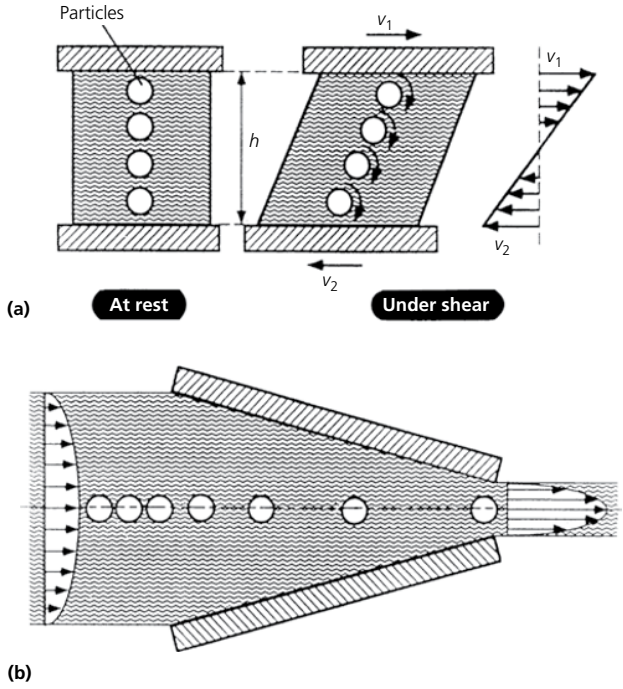

Figure 10.2 Representations of (a) simple shear and (b) elongational flow.

If a chocolate is mixed at a slow shear rate for a long time, the viscosity will come to an equilibrium level and remain there, so any further conching is not worthwhile, other than to bring about flavour changes. If the shear rate is increased this equilibrium viscosity is at a lower value and tends to be reached more quickly (Figure 10.3). Even higher shear rates may produce even thinner chocolate.

What this means for conche design is that higher shear rates, that is more work input into the chocolate produces thinner chocolates. This can be achieved by making the arms of the conche rotate faster or by decreasing the gap between the rotor blades and the conche wall. The former is obviously limited by the size of the motor, especially in the early stages of conching. The latter is limited by engineering precision and the need for a significant amount of the chocolate to be between the rotor and wall. The actual amount of chocolate being sheared by the rotors at any one time will, to a large extent, determine the conching time. Thus a narrow gap will produce a thin chocolate but will increase the time required to do so. There is also little point in having a very large conche when only a very small proportion of the chocolate mass is being sheared at any one time. The ratio of the mass of material being conched to the surface area being sheared is therefore important.