processes and the reaction at the electrochemical double layer. Therefore, the capacity of lead acid batteries depends strongly on the temperature. The capacity increases almost linearly by approximately 0.6%/K with an increase in temperature. The capacity decreases in the same way with decreasing temperatures. Depending on the battery technology, the temperature coefficient can be as high as 1.0%/K.

18.4.7.4 Ageing processes and their influence on the battery properties

A comparison with other battery systems, for example, NiCd batteries, reveals that the relatively short lifetime of lead acid batteries is a significant disadvantage. However, the operating behaviour of the batteries is already affected during the lifetime by the processes responsible for ageing. Thus, it is helpful to be aware of the most important ageing processes and to avoid the conditions that accelerate them.

18.4.7.4.1 Acid stratification

Acid stratification is not an ageing process but affects the operating behaviour of the battery. On one hand it reduces the available capacity and changes the current/voltage characteristics. On the other hand it leads to inhomogeneous current distribution at the electrodes. The latter effect accelerates sulphation (Section 18.4.7.4.2), which is a major ageing effect. Therefore, acid stratification is a reason for ageing and not an ageing effect by itself. Acid stratification in flooded batteries can be removed immediately by stirring the electrolyte.

Because the electrolyte functions as an active component of the electrode reaction, local variations in the density can arise, with the result that the acid density decreases in the upper part of the cell and increases in the lower part. The potential difference associated with the concentration difference leads to discharging of the lower section of the electrodes, which can result in irreversible ageing effects (e.g. sulphation).

In batteries with liquid electrolytes, the acid stratification can be eliminated by deliberate overcharging, associated with gas production. The same mixing effect can be achieved by active circulation of the electrolyte. Such electrolyte stirring systems are made from an air bubbling system (Figure 18.22).

Electrolyte stratification can also occur in batteries with immobilised electrolytes. In a gel battery, the effect is very small and therefore is of little relevance. In AGM batteries, the strength of acid stratification depends very much on the quality of the glass mat. Large battery cells from AGM technology are mounted vertically to avoid any acid stratification. While purchasing the batteries, it is important to check the manufacturer's specifications regarding vertical installation of the battery. The problem with VRLA batteries is that an existing acid stratification cannot be removed.

From theoretical consideration [19, 20], it is obvious that small currents in conjunction with acid stratification lead to a significant undercharging of the lower part of the electrodes. This effect is getting more and more pronounced with smaller battery currents. When an acid stratification occurs, the upper part of the electrodes is charge preferential and the lower part is discharge preferential. This results in differences in the local state of charge between the upper and the lower part of up to 30%. During the limited charging