CHAPTER 5

# FLOTATION

## INTRODUCTION

Flotation is used to remove suspended solid from waste water and to concentrate sludge.

Thus flotation offers an alternative to sedimentation, especially when the waste water contains fat and oils.

Either a portion of the waste water or the clarified effluent is pressurized at 3-6 atm. When the pressurized water is returned to atmospheric pressure in a flotation unit air bubbles are created. The air bubbles attach themselves to floc particles and the air-solute mixture rises to the surface, where it can be skimmed off, while the clarified liquid is removed from the bottom of the flotation tank.

As the solubility of air in water is proportional to the pressure, p, and inversely proportional to the absolute temperature, T, the quantity of air, $A_p$, which will be dissolved in the water can be calculated from the following equation:

$$A_p = A_1 \cdot \frac{293}{T} p_1 \qquad (5.1)$$

where $A_1$, is the solubility of air at $293^{\circ}K$ and 1 atm. $A_p$ and $A_1$ are given as g per l water or l (at $273^{\circ}C$ and 1 atm.) per l water.

The quantity of air released from the solution per liter or $m^3$ of water, $Q_{air}$, when the pressure is reduced can be found from:

$$Q_{air} = A_p - A_1 = A_1\left(\frac{293 \cdot p}{T} - 1\right) \qquad (5.2)$$

Since the solubility of air in waste water may be less than in distilled water, a correction factor should be applied:

$$Q_{air} = A_1\left(\frac{293 \cdot p \cdot f}{T} - 1\right) \qquad (5.3)$$

where f is the fraction of saturation achieved relative to the solubility in distilled water.

Hayes (1956) has shown that the degree of saturation is related to the design of the pressure tank. However, the use of packing can produce 90% saturation (Vrablick, 1959).

## Design of the flotation unit

Fig. 5.1 shows a flotation system with partial recirculation of the effluent. Generally it is necessary to estimate the flotation characteristics of the waste water by use of a laboratory flotation cell:

1) The rise of the sludge interface must be measured as a function of the time. An example is shown in Fig. 5.2.
2) The detention time must be varied and the corresponding saturation of pressurized water determined, see Fig. 5.3.
3) The effluent quality must be determined as a function of the air/solids ratio, see Fig. 5.4.

Based on such results it is possible to scale up as demonstrated in example 5.1.

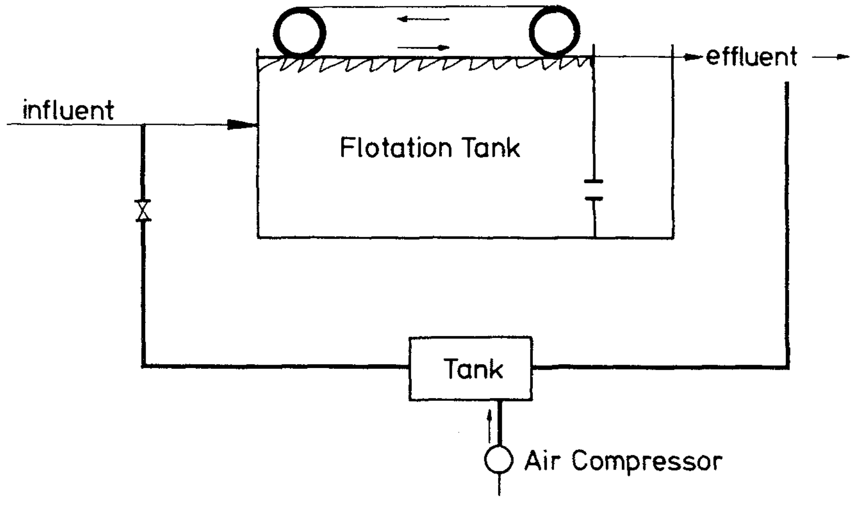


Fig. 5.1. Flotation unit.

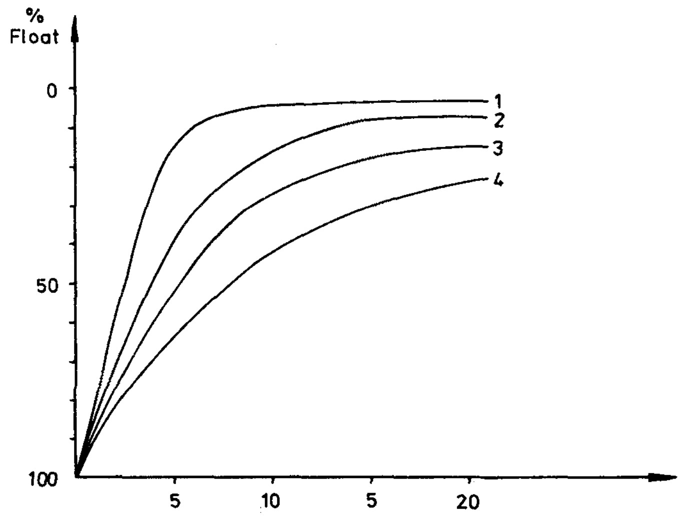


Fig. 5.2. Rise characteristics of paper fibres at four different air/solids ratios. 1) 0.03, 2) 0.06, 3) 0.16 and 4) 0.30.

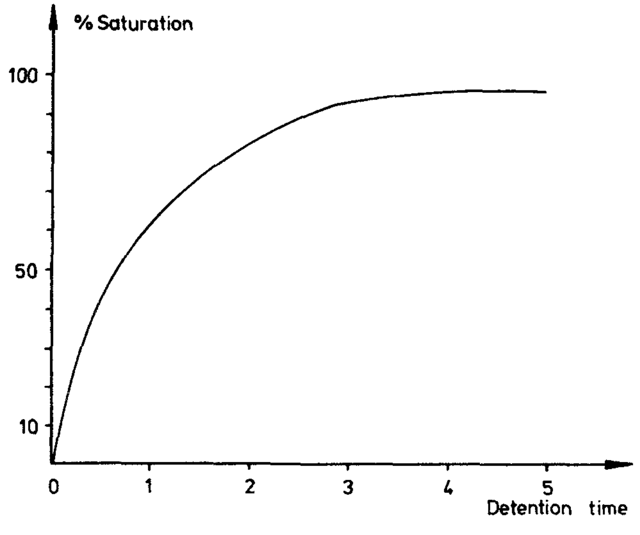


Fig. 5.3. Saturation plotted to detention time. (Paper fibres, pressure = 9 atm.). Detention time is indicated in minutes.

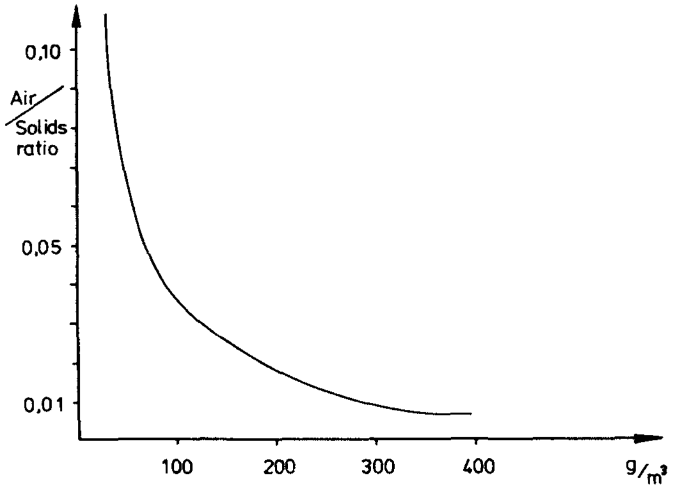


Fig. 5.4. Effluent quality versus air/solids ratio. Results of laboratory experiments on 550 mg/l waste water from a paper machine.

It is convenient to use the dimensionless air/solids ratio for the design of the flotation facility. This ratio can be calculated from the following equation:

$$\frac{A}{S} = \frac{A_1(fp - 1)V_p}{Q \cdot C_s} \qquad (5.4)$$

where

$\frac{A}{S}$ = air/solids ratio

$V_p$ = volume of pressurized air/time unit

Q = flow of waste water

$C_s$ = concentration of solid in inflow (g/m$^3$)

Fig. 5.5 gives $A_1$ as cm$^3$/l at various temperatures.

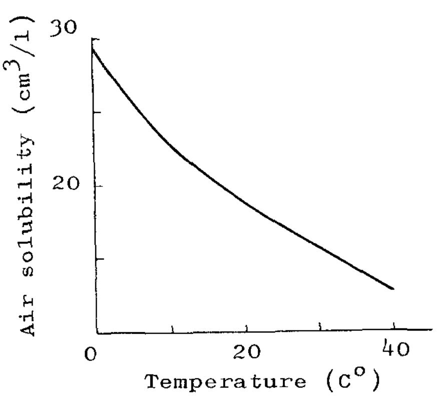


Fig. 5.5. Solubility of air in water at various temperatures.

Example 5.1

Design a flotation unit recovering fibres from a paper-making plant. The quantity of water is 1.2 $m^3$/min. Figs. 5.2 to 5.4 are the results of laboratory experiments on waste water containing 550 mg/l of fibres. $t = 20^{o}C$, $p = 9$ atm.

Solution

From Fig. 5.5: $A_1 = 18.7\ cm^3/l = 18.7\ l/cm^3 \sim 24.2\ g/m^3$.

An air/solids ratio of 0.06 is chosen (the choice is based on Figs. 5.2 and 5.4).

The corresponding effluent quality is 60 $g/m^3$.

A detention time of 4 min is chosen, giving $f = 0.95$ (Fig. 5.3).

$$0.06 = \frac{A}{S} = \frac{24.2\ (0.95 \cdot 9 - 1) \cdot V_p}{1.2 \cdot 550}$$

$$V_p = 0.22\ m^3/min$$

As the detention time for pressurized water is 4 min, a tank with a volume of at least 0.88 $m^3$ is required.

From Fig. 5.2 it is seen that a detention of 15 min is required to get a good separation. This means that a flotation tank of 18 $m^3$ must be used.

The sludge concentration, $C_c$, can be calculated from a mass balance, since the sludge volume is 7.5% of the water volume (see Fig. 5.2):

$$\frac{7.5}{100} \cdot 1.2 \cdot C_c + 1.2 \cdot \frac{92.5}{100} \cdot 60 = 1.2 \cdot 550$$

$$C_c = 6600\ g/m^3$$

REFERENCES

Hayes, T.T., 1956. Sewage Ind. Wastes, 28: 100.
Vrablik, E.R., 1959. Proc. 14th Ind. Waste Conf., Purdue Univ.