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Application of flotation as a pretreatment process during desalination

Efrosyni N. Peleka*, Kostas A. Matis

Section of Chemical Technology, School of Chemistry, Aristotle University, P.O. Box 116, GR-54124 Thessaloniki, Greece
email: peleka@chem.auth.gr

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Abstract

The need for fresh sources of drinking water is becoming more and more urgent worldwide, including certainly many areas and/or countries across the Mediterranean sea. Reverse osmosis membranes, on the other hand, are known to be very sensitive to foulants as colloids, inorganic scale and biofouling; so, pretreatment of their seawater feed is often a key step. In desalination plants design, various techniques have been proposed for pretreatment, even other membranes such as ultrafiltration. Nevertheless, may be among the more conventional belongs nowadays flotation (usually, in its dissolved-air option for bubbles generation), followed by filtration and preceded by screening. Flotation constitutes a high rate, effective and familiar separation process for oil, grease and suspended solids, like the algae. In potable water treatment, the process chain of flocculation–flotation–filtration is rather a common concept. The present paper will be a review of this interesting area with focus on sustainable development.

Keywords: Dissolved-air flotation; Solid/liquid separation; Potable water; Membranes

1. Introduction

The importance of flotation process to the economy of the whole industrial world is considered to be enormous. Without this process, many familiar metals and inorganic raw materials would be exceedingly scarce and costly, because the high-grade ores that could be processed by simple physical and mechanical methods have long since been used up. So, flotation initially originated from the field of mineral processing, usually termed froth flotation. It may be true that there is a gap between froth (dispersed-air) flotation and dissolved-air flotation; may be even for historical reasons and this was the sub-theme of the 2001 UEF Flotation conference held in

*Corresponding author.

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Tahoe City, California, organized by Profs. R.W. Smith and J. Rubio.

Since for many years various particulate solids besides minerals have been extracted from water by using this effective gravity separation method that is based on the idea of applying rising gas bubbles as the transport medium; the attachment of bubbles to particles transfer the solids from the body of water to the surface. As opposed to settling, flotation is a solid–liquid separation technique that is applied to particles whose density is lower or has been made lower than the liquid they are in. These flotation applications include mainly the treatment of water and wastewater. Today, for example, applications of flotation exist in paper manufacturing for deinking and waste paper recycling, emulsified oil from various industrial wastewaters and the separation of used plastics [1,2].

Silt density index (SDI, according to ASTM) is an easy and useful tool for particle evaluation and has been widely applied to determine the fouling characteristics of membranes. For a satisfactory separation various chemicals are used and among them, surfactants applied often as collectors in flotation; the latter are known surface-active compounds, being usually petroleum-based synthetic products. These are capable of reducing surface and interfacial tension between liquids, solids and gases, thereby allowing flotation (a three-phase system). Tightening environmental regulations and increasing awareness for the need to protect ecosystems have effectively resulted towards the examination of the fate, behaviour and effects of surfactants and their degradation products in the environment [3].

Scope of the present work is to investigate the possibility of flotation in seawater desalination pretreatment. Pretreatment of seawater feeding reverse osmosis membranes is a key step in designing desalination plants.

2. The flotation process

The typical classification of flotation is according to the method used for the generation of bubbles; so, two broad categories exist:

(a) dispersed-air flotation (including electroflotation), and
(b) dissolved-air flotation — just the initials are often used, as DAF (see Fig. 1a). The idea is based on Henry's law and the design resembles a chemical reactor with recycle. The specific design of the air release device generating the fine bubbles is also stressed. These two methods are essentially two different techniques regarding the bubbles size, flow conditions, separation aim and economics [4].

The trend in the development of DAF technology for potable water is to move to very thick micro-bubble beds with high flow rates, even advertised as the 3rd generation technology [5]; a flow rate of more than 60 m/h was given, where flotation operation is said to approach "turbulent" flow conditions. A compact (downstream filtration being in the same basin) re-flotation plant with hydraulic flocculation was built for instance for Tampere Finland water and sewerage works in 1997, by the company OY Rictor AB (as presented by Suutarinen in conference Ref. [5]). One of the advantages of flotation is its speed, hence its ability to operate inside a factory (Fig. 1b). The process reduces space requirements, saves operation and maintenance costs (according to the company) and improves purification results, being suitable for any kind of water.

An innovative hybrid flotation–microfiltration cell has been recently proposed for cleaning wastewater, combining the advantages of flotation and microfiltration for solid/liquid separation; where the membranes step was replacing the more traditional filtration. The main operational characteristics were studied, including the liquid and gas superficial velocities, and backflushing [6,7].