IMAGING TECHNOLOGIES

Techniques and Applications in Civil Engineering

PROCEEDINGS OF
THE SECOND INTERNATIONAL CONFERENCE

Sponsored by
The Engineering Foundation
and
The American Society of Civil Engineers
Technical Council on Computer Practices
Imaging Technologies Committee

Approved for publication by the Technical Council on Computer Practices of the American Society of Civil Engineers

Cresta Sun Hotel, Davos, Switzerland
May 25–30, 1997

EDITORS
J. David Frost
Sue McNeil

ASCE American Society of Civil Engineers
1801 ALEXANDER BELL DRIVE
RESTON, VIRGINIA 20191

Abstract: This document is intended to provide the civil engineer with a comprehensive and up-to-date perspective on the use of imaging technologies for solving civil engineering problems. This proceedings includes the papers submitted to the Second International Conference on Imaging Technologies: Techniques and Applications in Civil Engineering, sponsored by the Engineering Foundation and the American Society of Civil Engineers. Held at the Cresta Sun Hotel in Davos, Switzerland, from May 25-30, 1997, the conference was organized by the Imaging Technologies Committee of the Technical Council on Computer Practices of the ASCE. The conference provided an opportunity to continue the technical interaction initiated during the First International Conference held in Hawaii in March, 1993. The Davos meeting agenda included topics ranging from material characterization, deformation measurements, pavement distress, infrastructure maintenance, object recognition, particle sizing and image generation.

ibrary of Congress Cataloging-in-Publication Data

naging technologies: techniques and applications in civil engineering: proceedings of the second international onference, Cresta Sun Hotel, Davos, Switzerland, May 25-30, 1997/edited by J. David Frost and Sue McNeil.
p. cm.
Proceedings of the Second International Conference on Imaging Technologies: Techniques and Applications Civil Engineering. Sponsored by the Engineering Foundation and the American Society of Civil Engineers, chnical Council on Computer Practices, Imaging Technologies Committee.
Includes bibliographical references and index.
ISBN 0-7844-0325-2
1. Civil engineering--Instruments--Congresses. 2. Imaging systems--Congresses. I. Frost, J. David. McNeil, Sue. III. Engineering Foundation (U.S.) IV. American Society of Civil Engineers. Technical uncil on Computer Practices. Imaging Technologies Committee. V. International Conference on Imaging hnologies: Techniques and Applications in Civil Engineering (2nd: 1997: Davos, Switzerland)
165.I49 1998
-dc21

97-46793
CIP

of Congress Catalog Card No: 97-46793
7844-0325-2
ctured in the United States of America.

FOREWORD

The Engineering Foundation and the National Science Foundation co-sponsored a conference entitled "Digital Image Processing: Techniques and Applications in Civil Engineering" that was held in Hawaii in March, 1993. The purpose of the conference was to provide an opportunity for researchers and practitioners from academia, government and industry to convene and exchange information and ideas. Despite the fact that there were a significant number of people beginning to use image processing techniques in a range of civil engineering applications at that time, there had never been a meeting of the type held. The conference thus provided an efficient means for transfer of information between those already actively using the technology, as well as to inform those considering use of digital image processing of the potential benefits. The proceedings of the conference were published by ASCE in 1993.

To facilitate continued exchange of information and ideas, the Second International Conference on Imaging Technologies: Techniques and Applications in Civil Engineering was held in Davos, Switzerland in May, 1997. As with the first meeting, the intent was to create an opportunity for practitioners and academicians from a variety of agencies to learn of continued developments and applications in the field. As with all Engineering Foundation conferences, the meeting agenda included significant opportunities for ad-hoc discussion among the participants as well as more structured sessions with presentations of technical papers submitted by participants in topics ranging from material characterization, deformation measurements, pavement distress, infrastructure maintenance, object recognition, particle sizing and image generation.

The opening keynote lecture was given by Professor Murat Kunt from the Swiss Federal Institute of Technology in Lausanne. His presentation entitled “Image Coding: From Pixels to Objects” provided an excellent summary of classical compression techniques as well as a glimpse of where the field is headed, particularly with respect to dynamic coding techniques.

Contents

Application of Digital Image Analysis for Size Distribution Measurements of Microbubbles

Susan E. Burns[1], Sotira Yiacoumi[1], J. David Frost[1], and Costas Tsouris[2]

act

This work employs digital image analysis to measure the size distribution of bubbles generated by the process of electroflotation for use in solid/liquid ıtion processes. Microbubbles are used for separations in the mineral ssing industry and also in the treatment of potable water and wastewater. As ıbbles move upward in a solid/liquid column due to buoyancy, particles collide nd attach to the bubbles and are carried to the surface of the column where they moved by skimming. The removal efficiency of solids is strongly affected by ze of the bubbles. In general, higher separation is achieved by a smaller bubble The primary focus of this study was to characterize the size and size ution of bubbles generated in electroflotation using image analysis. The study that bubble diameter increased slightly as the current density applied to the ı was increased. Additionally, electroflotation produces a uniform bubble size arrow distribution which optimizes the removal of fine particles from solution.

uction

Many environmental and industrial treatment processes rely on the separation d particles from liquid solutions. Traditionally, solid particles are removed by entation; however, sedimentation does not work well for low density particles ay minerals, spores, and coagulated fulvic acids (Edzwald et al., 1992; Malley dzwald, 1991; Letterman, 1987). As a result, a method known as flotation, floats rather than sediments low density particles, is being used more only. In flotation, small gas bubbles are generated at the bottom of the water n to be treated. The microbubbles then rise to the surface of the liquid through ncy. As the bubbles rise, they collide with and adsorb to particles in the

ate Research Assistant and Associate Professors, respectively, Georgia Institute of ogy, School of Civil and Environmental Engineering, Atlanta, GA 30332-0355
cal Technology Division, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 226

solution; consequently, the low density solids are floated to the top of the column for removal by skimming. The process of flotation is known as dissolved air flotation if the microbubbles are produced by pressurizing air into water, as dispersed air flotation if the bubbles are produced by forcing gas through a sparger, and as electroflotation if the bubbles are produced through the electrolysis of water. This study will focus on bubbles generated by electroflotation.

Electroflotation has been used by the mineral processing industry for the recovery of mineral particles (Ketkar et al., 1991), and in environmental and industrial processes for the separation of oil from oil/water emulsions (Hosny, 1992; Balmer and Foulds, 1986), and for the removal of coagulated heavy metals from solution (Srinivasan and Subbaiyan, 1989; Ramadorai and Hanten, 1986). In all of these applications, the removal efficiency is strongly affected by the size of the generated bubbles. Smaller bubbles have a longer residence time in the system, have a larger surface area, and are more likely to adhere to solids after a collision (de Rijk et al., 1994). Consequently, the treatment process is optimized by generating the smallest diameter bubbles possible.

This paper examines the effect of the process variables of voltage, current, and ionic strength on the size of the bubbles generated during electroflotation. Bubble images were recorded with a long-distance, high-magnification microscope, and were printed and imported into a digital image analysis system for measurement of equivalent bubble diameter. The average equivalent circular diameter for was calculated for each experimental condition; additionally, the volume distribution of the bubbles was calculated for each experiment.

Experimental

The rectangular test cell used in the experiments of this study was made of Plexiglas with dimensions of 58.4 cm by 7.6 cm by 2.5 cm. Inflow and outflow ports were drilled in the top and bottom of the cell and it was mounted vertically in order to allow gas flow out the top. After the cell was filled with the test solution, a soap-film flow meter was attached to one outflow port to measure gas flow rate and the remaining outflow ports were sealed. The electrodes used in the experiments were polished graphite electrodes (7.6 cm by 2.5 cm by 1.3 cm) and were mounted at the bottom of the cell with a separation of 13 cm. Electrical leads were attached to the electrodes using conductive epoxy, and then connected to an external power supply.

Twenty eight experiments were performed using aqueous solutions of deionized water mixed with Na_2SO_4 at ionic strengths of 0.1, 0.01, and 0.001 M. In the experiments, the voltage was varied from 15 to 86 V and the current was varied from 11 to 288 mA. Current was applied to the system using a high-voltage, high-current power supply and the generated bubbles were videotaped using a long-

nce microscope with a magnification of approximately 230 times attached to a
› camera, monitor, and VCR. The calibration factor was a wire of known
eter. The experiments performed at 0.001 M did not produce a significant gas
rate; consequently, only the results for the experiments performed at 0.1 and
M are reported in this paper.

The gas bubbles produced in electroflotation form through the electrolysis of
r by the following redox reactions:

$$H_2O \rightarrow 2H^+ + \tfrac{1}{2}O_2(g) + 2e^- \qquad \text{Anode}(+)$$
$$2H_2O + 2e^- \rightarrow 2OH^- + H_2(g) \qquad \text{Cathode}(-)$$

oxygen and hydrogen gas dissolve into the liquid surrounding the electrodes;
ı the liquid becomes supersaturated with gas, bubbles begin to form on the
rode surface (Verhaart et al., 1980). The camera was focused on the bottom
rode in the test cell and two experiments were performed at each power level. In
first experiment, the bottom electrode was the anode, and in the second
riment the electrical leads were reversed making the bottom electrode the
ode. This configuration was used because it prevented the mixing of oxygen and
ogen bubbles during videotaping. A light source was set up behind the cell to
uce contrast between the bubbles and the solution in the recorded images.

ze Processing and Analysis

After the experiments were completed, the images were printed to hard copy
g a video copy processor and imported into a Quantimet Q570 Digital Image
cessor. The printed images were gray-scale pictures of dark bubbles on a light
ground because the light source behind the cell was blocked by the bubbles but
ed through the aqueous solution. After the images were acquired by the image
cessor, they were converted from gray-scale into digital images and a minimal
unt of image processing was performed. In some instances, background noise
urred on the images and was erased. Additionally, sometimes two bubbles
hed each other on the images. In this case, the bubbles were either separated and
yzed individually, or were eliminated from the image. No other image
cessing was performed on the bubble pictures. Because not all of the bubbles
e circular in cross-section, the image analyzer measured the area of each bubble
converted that to an equivalent circular diameter for the output.

A statically valid sample size was chosen for analysis by first determining the
r in the measurement. Measurements of one experiment were performed twice
the difference was 1.9 μm between the average diameters measured. Assuming a
mal distribution, and choosing a 95 % confidence interval, the sample size was
ulated by the following (Hines and Montgomery, 1990):

$$n = \left(\frac{Z_{\alpha/2}\,\sigma}{E}\right)^2, \qquad (1)$$

where n = sample size, $Z_{\alpha}/2$ = confidence interval, σ = standard deviation, and E = error.

Results

Figure 1 shows a plot of the equivalent circular diameter of oxygen bubbles as a function of current density. The figure shows a trend of slightly increasing bubble diameter with increasing current density applied to the system. This is consistent with other electroflotation results using metallic electrodes (Brandon and Kelsall, 1985; Janssen and Hoogland, 1973; Landolt et al., 1970). The formation of bubbles in electroflotation is an inhomogeneous, or surface controlled, process rather than a homogeneous process where the bubbles form out of solution without the presence of a surface. Previous research has found that bubbles will form at the location of scratches and pits on the electrode surface (Janssen and Hoogland, 1973; Glas and Westwater, 1964) which illustrates the importance of the surface characteristics of the electrodes. In this study, the electrodes were not polished between successive experiments which most likely explains the scatter seen in the average bubble diameter measurements, because the application of current will affect the surface characteristics of the electrode. Average oxygen and hydrogen bubble diameters measured in the experiments ranged from 17.1 to 37.9 μm, which is consistent with the size of bubbles produced on stainless steel and platinum electrodes (Ketkar et al., 1991).

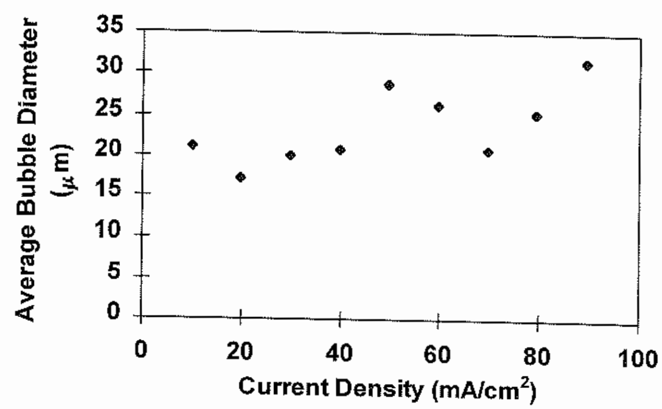

Figure 1. Oxygen bubble diameter as a function of current density: I = 0.1 M.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase® Smarter legal research.