PROSIDING
SEMERNAR NASIONAL
TEKNOLOGI INFORMASI DAN APLIKASINYA
Volume 4

Malang, 26 April 2012
PERAN PENGEMBANGAN
APLIKASI TEKNOLOGI INFORMASI
DALAM MEMBANGUN KARAKTER BANGSA

Diorganisasi oleh:
POLITEKNIK NEGERI MALANG
DEWAN REDAKSI

KETUA
Dr. M. Sarosa, Dipl. Ing., MT.

REVIEWER/KOMITE PROGRAM
- Prof. Dr. Bambang Riyanto (ITB)
- Dr. Ir. Syaad Patmanthara (UM)
- Dr. Agung Darmawansyah (UB)
- Dr. Ir. Agnes Hanna P., MT.
- Dr. Ir. R. Edy Purwanto, MSc.
- Dr. M. Sarosa, Dipl. Ing., MT.
- Dr. M. Maskan, MSi.
- Dr. Anggit Murdani, ST, M.Eng.
- Dr. Andriani Parastiwri, B.SEET, MT
- Dr. Kartika Dewi Sri S., SE, MBA
- Ir. Achmad Chumaidi, MT

KOMITE ORGANISASI
- Dr. Anggit Murdani, ST, M.Eng.
- Hendra Pradibita, SE, MSc.
- Mila Fauziyah, ST., MT.
- Fauziah Shanti Cahyani Siti Maisarah, ST, MT.
- Mila Kusumawardani, ST., MT
- Anang Takwanto, ST., MT
- M. Junus, ST. MT.
- M. Nanak Zakaria, ST., MT.
- Akhmad Faizin, Dipl. Ing. HTL., MT.
- Drs. Joko Samboro, MM
- Yoyok Heru Pr, Drs., MT.
- Windi Zamrudy, B. Tech., MPd.
- Ir. Deddy Kusbianto PA, MMKOM.
- Ratna Ika Putri, ST, MT.
- Zakijah Irfin, ST., MT
- M. Taufik, ST., MT
- Ahmadi Yuli Ananta, ST
DAFTAR ISI

HALAMAN JUDUL
KATA PENGANTAR
SAMBUTAN DIREKTUR POLITEKNIK NEGERI MALANG

A. ELEKTRONIKA DAN SISTEM KENDALI

1. OBJECT ORIENTED PROGRAMMING FOR THE INTERNAL ADC OF AVR ATmega8
   SIDIK NURCAHYO
   A-1

2. PROTOTIPE PEMBANGKIT LISTRIK TENAGA GELOMBANG DENGAN METODE PELAMPUNG
   SUROJO
   A-5

3. PEMODELAN SVPWM INVERTER SEBAGAI PENGGERAK MOTOR INDUKSI TIGA FASA ROTOR
   SANGKAR BERBASIS METODE VECTOR CONTROL
   ARIPRIHARTA, RINI NUR HASANAH, TEGUH UTOMO
   A-10

4. PENGASAPAN IKAN DENGAN KONTROL LOGIKA FUZZY BERBASIS MIKROKONTROLER
   THORIQ TAMIMI, HENDIKA EKO H.S., M. SAFRODIN
   A-16

5. PENGATURAN NILAI KEKEENTALAN PADA PRODUKSI GULA MENGGUNAKAN METODE BOLA JATUH
   M. IEDUL MUBARROK, SUTEKO, RENNY RAKHMAWATI
   A-23

6. ALAT PERAGA POSISI LENGAN ROBOT BERBASIS ARDUINO-ETOYS UNTUK PEMBELAJARAN KINEMATIKA
   PIPPIE ARBIYANTI, DIAN ARTANTO
   A-29

7. PROTOTIPE RANCANG BANGUN SISTEM PENGATURAN TEKANAN AIR PADA SISTEM PERUMAHAN MANDIRI
   SUROJO, RENNY RAKHMAWATI, RIKI KHARIS AGUNG
   A-32

8. DESIGN AND ANALYSIS OF THE EDF SCHEDULER FOR SAFETY CRITICAL SYSTEMS ON AN X86 EMBEDDED PC ARCHITECTURE
   SAPTO WIBOWO
   A-39

9. APLIKASI FUZZY LOGIC UNTUK PENGATURAN PENCAHAYAAN NEONBOX BERDASAR PEMESANAN DAYA
   YAHYA CHUSNA ARIEF, EKA PRASETYO, MUHAMAD AGUS WIDODO
   A-45

10. DEVELOPING MUSICAL ALARM USING EMBEDDED BOARD MINI2440
    SIDIK NURCAHYO
    A-51

11. IMPLEMENTASI PENGONTROL POSISI LAMPU DENGAN REMOTE PADA RUANG OPERASI
    TOTOK WINARNO
    A-57

12. RANCANG BANGUN BUCKBOOST KONVERTER BERBEBAN MOTOR DC MENGGUNAKAN KONTROL LOGIKA FUZZY
    AINUR ROFIQ NANSUR, ENDRO WAHIONO, PUTRI ARDANI WULAN C
    A-63

13. PEMICUAN SUDUT FASA UNTUK MENGATUR DAYA HEATER
    BERBASIS AVR ATmega8
    TUNDUNG SUBALI PATMA, SIDIK NURCAHYO
    A-69
ALTERNATIF PENGHEMATAN DAYA LISTRIK DENGAN METODE MULTIPLEXING PADA BEBAN LAMPU HEMAT ENERGI
EKA MANDAYATMA
A-73

DESIGN OF PROCESS EQUIPMENT FOR EGG INSEMINATION WITHOUT THE CONTRIBUTION OF GENETIC MALES IN FISH HATCHERIES
R. EDY PURWANTO
A-77

HYBRID PHOTOVOLTAIC (PV) AND DIESEL GENERATOR FOR SMALL SCALE IRRIGATION, WATER PUMPING SYSTEM
JABER MELOUD GLAIL
A-81

CONVENTIONAL ENERGY OF LIBYA AND ITS EXPECTED JABER MELOUD GLAIL
A-85

B. INFORMATIKA DAN KOMPUTER

RANCANG BANGUN PEMBACAAN PLAT NOMOR KENDARAAN MENGGUNAKAN METODE PENCOCOKAN POLA
GRASTIKA SELVIA, RAHAJENG NAWANG
B-1

APLIKASI MOBILE LEARNING TUTORIAL TOEFL MENGGUNAKAN FEATURE HANDPHONE YUANITA DEWI KARTIKA, M. SAROSA, YANI RATNAWATI
B-7

APLIKASI WEBGIS SEBAGAI PENYEDIA INFORMASI BTS UNTUK WILAYAH MALANG RAYA LAURA SILVIA FEBRIANTI
B-14

STUDI POTENSI PENGEMBANGAN PEMBANGKIT LISTRIK TENAGA MIKROHIDRO SALURAN IRIGASI DI KECAMATAN PAKIS KABUPATEN MALANG GATOT JOELIANTO, ANDRIANI PARASITI, ACH. MUHIB ZAINURI
B-20

PENGEMBANGAN SISTEM ABSENSI METODE FINGER PRINT DENGAN PROTOCOL TCP/IP NENY EKO WARYUNI
B-25

METODE SURVEI GPS UNTUK PEMETAAN ALIRAN IRIGASI SEBAGAI DATA MASUKAN SISTEM INFORMASI GEOGRAFI EKOJONO, ANDRIANI PARASITI
B-30

INTERAKSI VIRTUAL DAN AKTUAL BERBASIS ARDUINO-ETOYS UNTUK PEMBELAJARAN PEMROGRAMAN DIAN ARTANTO, PIPPIE ARBIYANTI
B-36

PENGENDALIAN SISTEM PELAYANAN KESEHATAN MASYARAKAT MISKIN BERBASIS BIOMETRIC SECURITY DI KOTA MATARAM ABD. MANAN, HERO SANTOSO, DYAH SOSILOWATI
B-41

PEMAMFAATAN SISTEM INFORMASI BERBASIS WEB DALAM LAYANAN PENJUALAN ONLINE BAGI PEDAGANG PASAR BUNGA EX-BARITO JAKARTA GUNA MENINGKATKAN LAJU PERTUMBUHAN LABA MARZUKI
B-48

VISUAL BASIC UNTUK SIMULASI INTERAKTIF PEMODELAN KEMAMPUAN VEGETASI MEREDAM KEBISINGAN UTAMI RETNO PUDIOWATI, MUTIA LINA DEWI
B-54

STUDI PENGARUH PENERAPAN E-LEARNING DI POLINEMA DEDDY KUSBIANTO PURWOKO AII
B-59

SISTEM INFORMASI PERENCANAAN PARIWISATA PANTAI KONDANG MERAK, MALANG, JAWA TIMUR IBNU SASONGKO
B-65

VI
PERANCANGAN DAN PEMBUATAN SISTEM TRACKING OBJEK BERDASARKAN PENGENALAN WARNA
DWIKY HERLAMBANG, ERIN FAR(A), HAFID ANGG(A), P, YOYOK HERU PI, HENDRO DARMONO

SISTEM PAKAR IDENTIFIKASI HAMA DAN PENYAKIT TANAMAN ANGREK DENGAN METODE FORWARD CHAINING
DWI YUNANTO

MODEL IMPLEMENTASI CORPORATE PORTAL AKADEMIK DI LINGKUNGAN PERGURUAN TINGGI
YAN WATIE QULI SYAIFUDIN

PERANCANGAN SISTEM INFORMASI GEOGRAFIS PEMETAAN POPULASI PENDUDUK DAN KOMODO DI TAMAN NASIONAL KOMODO
AHMAT ADIL, ABOUL MANAN, HUSAIN

APLIKASI VISUALISASI PEMETAAN SEKOLAH DI KABUPATEN NUNukan KALIMANTAN TIMUR
ANDY PRAMONTO, BETTY DEWI PUSPASARI

PENGEMBANGAN KNOWLEDGE REPRESENTATION OWL BERBASIS DESCRIPTION LOGIC
M. ZAINAL ARIFIN

KALIBRASI KAMERA TUNGGAL MENGGUNAKAN TRANSFORMASI LINIER (DLT)
GIRO WAHYU WIRIATSO, ANDI KUSUMA INDRAWAN

APLIKASI IQRA MOBILE MENGGUNAKAN JAVA 2 MICRO EDITION (J2ME)
ELVINA, FAJR MASYA

ANALISA DAN DESAIN SISTEM MONITORING TUGAS AKHIR MAHASISWA DENGAN PENDEKATAN SERVICE ORIENTED ARCHITECTURE (SOA) BERBASIS WEB SERVICE
BAYU PRIYAMBODA

RANCANGAN DAN DESAIN INTEGRASI SISTEM INFORMASI PERGURUAN TINGGI SWASTA BERBASIS WIRELESS
MUHAMMAD TAUJIDIN, AHMAT ADIL, ABD. MANAN

INTERACTIVE ANIMATION MODULE TO LEARN ENERGY MANAGEMENT PRACTICES IN SMALL AND MEDIUM HOTEL
YUSAK TANOTO

APLIKASI MOBILE LEARNING BERBASIS ANDROID MENGGUNAKAN LAYANAN VIDEO PADA PERKULIAHAN
DENNY WIJANARKO, DJOKO SUPRAJITNO R, ACHMAD AFFANDI

PENGEMBANGAN BUSINESS INTELLIGENCE MENGGUNAKAN DASHBOARD PETA STUDI KASUS: FTIS-UNPAR
ADHE SANDHI, GEDE KARYA

SISTEM INFORMASI GEOGRAFIS DAERAH: PERENCANAAN SISTEM INFORMASI SPASIAL KABUPATEN LOMBOK BARAT SEBAGAI DISEMINASI PROFIL DAN POTENSI DAERAH UNTUK PENDUKUNG PENGELOLAAN PROGRAM PEMBANGUNAN
AGUS PRIBADI

KAJIAN KECEPATAN LAYANAN AKSES MOBILITY MEDIA MOBILE
RAMADHYTO WICAKSAN(A), SINDI IDRIANA HAPSARI

APLIKASI MOBILE UNTUK SEBAGAI PELAJARAN FISIKA SMP KELAS VII
ANDY PRAMONTO, DINNY PURWANINGSH

APLIKASI METODE ALGORITMA GENETIKA ADAPTIF UNTUK PENYUSUNAN JADWAL MATAKULIAH
YOYOK HERU PRASETYO ISNOMO

METODE FAKTORISASI MATRIK NON NEGATIF TERNORMALISASI PADA KLASTERISASI
DOKUMEN
DWI PUSPITASARI

TRACKING MATA UNTUK MENAMPILKAN OBJEK KACA MATA AUGMENTED REALITY
MENGUNAKAN HAAR CASCADE CLASSIFIER
SLAMET, MOCH. DHARIADI

VII
C. KELISTRIKAN

1. KAJIAN PEMANFAATAN PERANGKAT LUNAK OPENCSCADA PADA SISTEM TENAGA LISTRIK DI INDONESIA
   POPONG EFFENDRIK
   C-1

2. ANALISIS KINERJA PENYEРАRAH TIGA-FASA TERKONTROL PENUH DENGAN DFG METODE
   FUNGSI ALIH
   ASHURI
   C-5

3. SOLAR ENERGY ELECTRIC 4400VA, 220VOLTS, 50HERTZS WITH SLIVER CELLS AND
   CHANGEOVER SWITCH BASED PLC FESTO FC-34
   SUPRAPTO WIDODO, NURMAN ISMAIL
   C-10

4. DESAIN PERBAIKAN FAKTOR DAYA MENGGUNAKAN SOFT SWITCHED STATIC VAR
   COMPENSATOR DENGAN METODE SWITCHING KONTROL LOGIKA FUZZY
   AINUR ROFIQ, NANSUR, ST,MT., ENDRO WAHIJONO, SST, MT., HAPPY APRILLIA
   C-16

5. MEMPERBANYAK JUMLAH TERMINAL INPUT PROGRAMMABLE LOGIC CONTROLLER (PLC)
   DENGAN KOMBINASI INPUT-OUTPUT
   TRESNA UMAR SYAMSURI
   C-23

D. TELEKOMUNIKASI

1. DESAIN DAN SIMULASI ANTENA ULTRA WIDEBAND CIRCULAR MICROSTRIP ARRAY PADA
   RENTANG FREKUENSI (2.3 – 16.3) GHz
   MOHAMMAD TAUFIK
   D-1

2. PERANCANGAN ANTENA UWB (ULTRA WIDEBAND) BERBENTUK YIN
   RUDY YUWONO
   D-8

3. PERANCANGAN DAN PEMBUATAN ANTENA UWB MIKROSTRIP HALF RING CIRCULAR PADA
   FREKUENSI (1900 – 2400) MHZ UNTUK APLIKASI HSDPA
   RISKA PRATIDINA, HENDRO DARMO, KOESMARJLIANTO
   D-14

4. PENGUKURAN ANTENA GRID DENGAN DIPOLE SEBAGAI REFERENSI PADA FREKUENSI 2, 4 GHZ
   KOESMARJLIANTO, ABDUR ROHIM, NANANG SUJATMIKO
   D-20

5. PERHITUNGAN THROUGHPUT PENGGUNAAN KANAL PADA SISTEM KOMUNIKASI SELULER
   M. NANA ZAKARIA
   D-26

E. TEKNIK SIPIL

1. ANALISA STABILITAS LERENG PERUSAHAAN TEXTILE DI JAWA BARAT
   MUSTA'IN ARIF
   E-1

2. PERKUATAN LERENG ALAMI (SOIL BIOENGINEERING) MENGGUNAKAN VEGETASI
   GERARD APONNO
   E-6

3. PENGGUNAAN SISTEM INFORMASI GEOGRAFI DALAM ANALISIS KELAYAKAN LAHAN
   PERKOTAAN
   MARIA CHRISTINA ENDARWATI
   E-12
F. TEKNIK MESIN

1. PROBLEMATIKA POMPA BAHAN BAKAR MOTOR BENSIN
   SANTOSO

2. TEKNIK PENGUKURAN POTENSI TENAGA ALIRAN AIR DALAM STUDI KELAYAKAN
   RAHMAN AZIS PRASOJO, FAHRIZA AVIANTI, ANDRIANI PARASTIWI

3. PEMBANGUNAN PLTMH
   RAHMAN AZIS PRASOJO, FAHRIZA AVIANTI, ANDRIANI PARASTIWI

4. PERANCANGAN MODEL BIODIGESTER LIMBAH CAIR TAHU UNTUK PRODUKSI BIOGAS
   SHOOBIBUS ZUHRY, MEKO GERRY NOVARIANT, ERIQ SULTON EFFEYNDI, ANDRIANI PARASTIWI

5. WIRAUASA PEMULUNG MELALUI PENGEMBANGAN MESIN PERAJANG LIMBAH PLASTIK
   WIDJANKO

6. DENGAN METODE QUALITY FUNCTION DEPLOYMENT DAN VALUE ENGINEERING
   WIDJANKO

7. DYNAMIC BEHAVIORS OF MICRO AIR BUBBLES IN A STAGNANT VERTICAL WATER REACTOR
   FELIKSIANUS EKO WISMO WINTOBO, SYED IHTISHAM-UL-HAQ, GILANI

8. UPAAYA MEMBATASI TERJADINYA PENGERAAN PERMUKAAN PADA PROSES PEMBUBUTAN
   KECEPATAN TINGGI UNTUK BAHAN S 45 C
   MASKURI

9. ANALISIS GAYA POTONG PAHAT
   ENDMILL PADA PROSES MESIN MILLING
   RAHIBIN

10. PENYUSUNAN DAN PENGUKURAN PRIORITAS ATRIBUT KUALITAS PELAYANAN TERMINAL
    AGUNG SEDAYU, HARNEN SULISTIO, ACHMAD WICAKSONO, AGUS SOEHDJONO

11. STRATEGI PEMANFAATAN DIGESTER BIOGAS SEBAGAI ENERGI ALTERNATIF DI PEDESAAN
    BAMBANG SUGIYONO AGUS PURWOONO, SUYANTA

12. ANALISIS KEGAGALAN GRIPPER BOTOL MINUMAN KAPASITAS 600 BOTOL PER MENIT
    HAIR ARISWORO, AMINDOI PURNODANO, SUGIARTO

13. PENGARUH PASCA PEMBENGKOKAN (BENDING) TERHADAP KEKUATAN TARIK BAJA STRIP
    VINON VIHYUS

14. PENGARUH ASAM LEMAK BEBAS (ALB) TERHADAP PRODUKSI BIODIESEL DENGAN METODE
    METANOL SUPERKRITIS
    PONDI UDJANTO

IX
1. INTEGRASI PERANGKAT LUNAK UNTUK ESTIMASI BIAYA MANUFAKTUR
   AGUS HARJOITO

2. ANALISIS DESAIN RONGGA DIES UNTUK PENEMPAAN PRODUK CONNECTION ROD SEPEDA
   NURCHAIAT

3. PENGARUH CAMPURAN GAS TERHADAP SIFAT MEKANIK HASIL LAS PADA PROSES
   EKO HENDRY SUYONO

---

**G. TEKNIK KIMIA**

1. KINETIKA REAKSI ESTERIFIKASI MINYAK JARAK PAGAR DENGAN KATALIS H2SO4 DAN
   ADSORBEN SILIKA GEL UNTUK PEMBUATAN BIODIESEL
   ELVIANTO DWI DARYONO, MUYASSAROH, M. ISTNAENY HUIDHA

2. STUDI PENGGUNAAN METODE ELEKTROLISIS PADA TRANSESTERIFIKASI MINYAK SAWIT
   ANANG TAKWANTO

3. UPAWAYA PERPANJANGAN MASA SIMPAN PHANEROCHAETA CHRYSOSPORIUM DAN ZEOLIT
   ALAM YANG BERSINERGI UNTUK PENGOLAHAN LIMBAH TEKSTIL
   DWI NYOMENTAMARIA, NAINIK HENDRAWATI

4. PEMBUATAN PLASTIK KEMASAN RAMAH LINGKUNGAN DARI BAHAN DASAR PATI
   PROFYANTI HERMIEN SUHARTI, ZAKIYAH IRFIN

5. PEMBUATAN SERBUK EKSTRAK BUAH STROBERI (FRAGARIA CHILIOENSIS L. / F. VESCA L)
   WINDI ZAMRUDY

---

**H. EKONOMI DAN BISNIS**

1. PENGARUH FAKTOR FUNDAMENTAL TERHADAP HARGA SAHAM SYARIAH
   HABIBURROCHMAN, ZIDNI ARDHIANA FIRDaus

2. ANALISA STRATEGI PEMASARAN MENGGUNAKAN METODE SWOT PADA PT. KORINDO
   H. MAHRUF BUDIMARSOJO

3. CONTAGION DAN COMPETITIVE EFFECTS DALAM TRANSFER INFORMASI INTRA INDUSTRI:
   STUDI PERISTIWA ATAS PENGUMUMAN DIVIDEN
   RETNO WIDIASTUTI

4. MENGGUNAKAN EXCEL DALAM AUDIT
   ZAINAL ABDUL HARIS

5. PENGARUH BAURAN PROMOSI, FAKTOR INTERNAL DAN EKSTERNAL TERHADAP KEPUTUSAN
   NASABAH MEMILIH BANK SYARIAH DI KOTA MALANG
   MOHAMMAD MASNAD, ALIFULAHINTI UTAMININGSIH

6. ANALISIS WIRAUSAHA INDUSTRI PARIWISATA PANTAI
   NUNUNG NURASTUTI UTAMI

7. ANALISA KELAYAKAN FINANSIAL PROYEK PLTA (STUDI KASUS: PLTA 2 X 6,2 MV)
   FAUZIAH S.C.S. MAISARAH

8. ANALISA TATA KELOLA KETERSEDIAAN LAYanan TI DI POLITEKNIK NEGERI MALANG
   AHMAD FAUZI
<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONFIRMATORY FACTOR ANALYSIS DIMENSI VARIABEL KOMPETENSI SISWA SMA ISLMAMIC FULL DAY SCHOOL DI SURABAYA SITI MAHMUDAH</td>
<td>1-1</td>
</tr>
<tr>
<td>2</td>
<td>THE IMPACT OF TECHNOLOGY ON EDUCATION LIA AGUSTINA</td>
<td>1-7</td>
</tr>
<tr>
<td>3</td>
<td>APLIKASI PEMBELAJARAN BERBASIS ENSIKLOPEDIA MULTIMEDIA INTERAKTIF UNTUK ANAK-ANAK DIDIK DWI PRASETYA</td>
<td>1-13</td>
</tr>
<tr>
<td>4</td>
<td>PEMANFAATAN WEB SEMANTIC DALAM MENGIMPLEMENTASIKAN ONTOLOGY PADA SISTEM E-LEARNING BERNARD RENALDY SUTEJA, SURYO GURITNO, RETANTYO WARDYO, AHMAD ASHARI</td>
<td>1-18</td>
</tr>
<tr>
<td>5</td>
<td>PELATIHAN KETERAMPILAN ELEKTRONIKA BAGI PEMUDA KARANG TARUNA KELURAHAN GLADAK ANYAR KABUPATEN PAMEKASAN M. IBRAHIM ASHARI, A. FAISOL, NI PUTU AGUSTINI</td>
<td>1-24</td>
</tr>
<tr>
<td>6</td>
<td>MENGEMBANGKAN BAHAN AJAR ENGLISH FOR SPECIFIC PURPOSES (ESP) BERKARAKTER TUTUK WIDOWATI MENUMBUHKEMBANGKAN BANGSA KREATIF DENGAN MENCATAT YANG EFKETIF DIRANAH PEMBELAJARAN (TAWARAN SOLUSI PEMBELAJAR) HENNY PURWANINGRISIH PENERAPAN METODE SERVQUAL DALAM UPAYA PENINGKATAN PELAYANAN MAHASISWA POLITEKNIK NEGERI MALANG VINAN VIVI SISTEM INFORMASI BOOKING BUKU PERPUSTAKAAN BERBASIS WAP (WIRELESS APPLICATION PROTOCOL) FAJAR MASYA, ELVINA</td>
<td>1-30 1-36 1-43 1-49</td>
</tr>
</tbody>
</table>
Dynamic behaviors of micro air bubbles in a stagnant vertical water reactor

Felixtianus Eko Wismo Winarto, Syed Ihtsham-ul-Haq Gilani
Diploma of Mechanical Engineering, Vocation school of Gadjah Mada University, Universiti Teknologi Petronas,
Skud Unit I Yogyakarta, Indonesia. Corresponding
felixeko@yahoo.co.uk, syedihntsham@petronas.com.my.
Tel(0274)6491301, Fax(0274)580990

Abstract:

Milli and micro size bubbles show altogether different dynamic behavior in a vertical water column. Millimeter size air bubble adds turbulence and acts as water stirrer, due to high velocity components (horizontal and vertical) and frequent shape change. These parameters add an influence of high buoyancy force and low surface tension. A reduction in the bubble size (milli to micro) tends to change the upward velocity, buoyancy force, drag force and exhibit a little or no turbulence effect.

An experimental setup was established to study the development of fine air bubbles in a stagnant vertical water column. Porous sintered glasses with porosities of 1 to 40 μm, were used as diffuser to produce micro bubbles. To close the real wastewater physicochemical characteristics, the Glycerin in various volume fractions of 0.1% to 0.5% in distilled water was used. The relationships between Froude number and bubble velocity as well as Reynolds number and bubble diameter, show that the higher pollutant concentration in the water solution would decrease the bubble diameter and reduce the vertical velocity. These parameters (bubble diameter and vertical velocity) lead to high effectiveness of suspended particle separation, and are validated by measuring the low concentration of pollutant (PPM).

Keyword: milli and micro bubble, turbulence effect, porous sintered glass, submerged diffuser, polydisperse, polluted water, froude number, PPM decreasing.

1. Introduction

The motion of air bubbles in a vertical water column is dependent on the many forces acting on it. After the bubble detaches itself from its source, the main forces that act on it are buoyancy and drag. The buoyancy force mainly depends on the volume of the bubble and the drag force depends on the contact surface area of the bubble. Bigger bubble has higher buoyancy and drag force, both acting in opposite directions; this causes shape deformation. As the bubble becomes more deformed in the horizontal direction, the drag force would increase. The drag force appears as horizontal velocity and moves in a zig-zag pattern upward. This condition leads to turbulent flow and creates the stirring effect.

On the other hand, small bubble has a small buoyancy and drag force. There is almost no shape deformation; the bubble shape remains in a sphere form. The spherical bubble has the lowest velocity, and it has strong relationship between bubble shape and bubble velocity as shown by Kracht W., 2010. Compared to the bigger bubble, a smaller bubble has a better vertical movement due to negligible horizontal velocity. The other bubble shape is spheroidal or elliptical as studied by Tomiyama A., 2002 ; Alexander Zuniga, 2007. They found that the spheroidal bubbles have high Reynolds number. In comparison to spheroidal bubbles, spherical bubbles have low Reynolds number, i.e. laminar flow and negligible stirring effect. In this research this fine bubble has been found suitable for suspended particle separation.

Different types of forces act on a bubble at the time of bubble generation and the time of bubble detachment. Ideally, the bubble that emerges and travels up should have a spherical shape, but due to various forces acting on it, the bubble keeps on changing its shape. The various forces that act on a bubble before it detaches from a vertical wall have been reported by Fan, 1999; Vazquez A., 2010; Yeoh G.H., 2005. The forces acting at the time of detachment were investigated by J. Katz, 1996; Kracht W., 2010. Their studies have shown that shape stabilization is not instantaneous during the first 10-15 ms due to detachment force. This detachment force also produces bubble collision, excitation, and coalescence. The dynamic behaviour of equal-sized spherical bubbles interaction (merger, separation, pairing-off, repairing and oscillation) were investigated by Ruzicka, 2000. He reduced the air inlet pressure to control the period of bubble generation, and ensured that the vertical distance between bubbles was long enough to decrease the influence of the detachment force.
One of the reasons for bubble shape change is the amount of pollution in water. Pollutions change the physicochemical characteristics of water (surface tension, viscosity and density). The decreasing of surface tension and liquid viscosity, and the increasing of air density are subjected to reduce the bubble size, reported by Scafer R., 2002. An increase of the surface tension would generate bigger bubble Idogawa K., 1987. The application of different gases and variable pressure, and found that the bubble size decreased when there was an increase of the gas density Wilkinson P.M., 1991. The using of glycerine as a pollutant to study the bubble-particle collision forces [Hong T., 1998. The concentration level and the types of pollutant influencing the velocity and bubble shapes were studied by Kracht W., 2010.]

II. The objective of the research.

The objective of this research is the separation of suspended solid in the stagnant pollutant water by air micro bubble.

III. Methodology

B. Acting forces on bubbles

The bubble diameter and velocity are the main factors to be controlled for effective pollution separation. The hydrodynamic parameters (bubble size, bubble rising velocity, bubble formation frequency) are important parameters for controlling the flotation process in oily wastewater, Parmakulak P., 2009. Buoyancy and gas momentum forces act upward, while all other forces act downward.

Some porous diffuser has a rough surface, therefore a small part of the surface would be flat while the rest of the surface would be inclined. The forces acting on a bubble before the bubble detaches itself from the diffuser are detailed in Fig. 1, Table 1. Any inclination in pore position will produce enlarged bubble forces that will create bigger bubbles as formulated in equation 5.

TABLE 1. The forces influencing bubble generation and detachment.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
<th>Eq., when pore is in a vertical Position (Fig. 1a) ( \phi = 90^\circ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( F_B )</td>
<td>Buoyancy force</td>
<td>( F_B = \frac{\pi}{6} d_B^3 (\rho_l - \rho_g) g )</td>
</tr>
<tr>
<td>( F_M )</td>
<td>Gas momentum force</td>
<td>( F_M = \frac{\pi}{4} D_e^2 P_e u_e^2 )</td>
</tr>
<tr>
<td>( F_D )</td>
<td>Surface tension force</td>
<td>( F_D = C_A \left( \frac{\pi}{4} d_B^2 \right) \frac{\rho_u u_e^2}{2} )</td>
</tr>
<tr>
<td>( F_a )</td>
<td>Bassett force</td>
<td>( F_B = \pi D_a^2 \sigma \cos \theta )</td>
</tr>
<tr>
<td>( F_{BA} )</td>
<td>Bassett force</td>
<td>( F_{BA} = 0 )</td>
</tr>
<tr>
<td>( F_{IB} )</td>
<td>Bubble inertial force</td>
<td>( F_{IB} = \frac{d}{dt} \left[ \rho_B \left( \frac{\pi}{6} d_B^3 \right) u_8 \right] )</td>
</tr>
</tbody>
</table>

- \( C_D = \frac{24}{Re} \)

a. Vertical diffuser pore: The forces acting on a bubble at the time of generation in a vertical position pore diffuser can be formulated as below:

\[
\sum F_{vertical} = F_M + F_B - F_D \tag{1}
\]

Where \( F_M \) is momentum force and \( F_B \) is buoyancy force.

The momentum force of air inlet (\( F_{in} \)) would help to generate the bubble, and is dependent on cross sectional area of the diffuser pore, density of air, and velocity of air entering the diffuser.

The buoyancy force is dependent on volume of bubble, density differences between water and air and gravitational acceleration.

The effective bubble generation forces for a vertical diffuser pore are:

\[
\sum F_{pull-out} = F_M + F_B - F_D \tag{2}
\]

At the moment of detachment, the force acting on the bubble would be:

\[
\sum F_{det} = F_B + F_M - (F_B + F_M - F_B + F_A + F_B + F_D) \tag{3}
\]

b. Inclined diffuser pore (\( \phi \)): The forces acting on the bubble at the time of generation can be described into two directions i.e. vertical and horizontal. The horizontal and vertical forces acting on a bubble are:

\[
\sum F_{vertical} = F_M \sin \theta + F_B \tag{4}
\]

\[
\sum F_{horizontal} = F_M \cos \theta \tag{5}
\]

The generation of bubbles is dependent on three forces viz, momentum, surface tension and drag. The net force resulting from the interaction of the three forces is the effective bubble generation force, termed as \( F_{pull-out} \):

\[
F_{pull-out} = F_M - F_B - F_D \tag{6}
\]

At the time of detachment, the net force acting on the bubble would be:

\[
\sum F_{det} = F_B + F_M \sin \theta - (F_D + F_A + F_B + F_{BA} + F_{IB} + F_B + F_{IB}) \tag{7}
\]

Inclined diffuser pores always tend to generate bigger bubbles due to smaller bubble pull-out force and detachment force (equation 6 and 7) and enlarged bubble force (equation 5).
To classify the acting forces into lift force and drag force, a different lift coefficient (CL) for the same depths at different instances is found by Kulkarni A. A., 2008. The correlation of air bubble drag force and fluid flow in a venturi was investigated by Soubiran J., 2000, with the assumption that oscillations would not occur. The drag and virtual mass forces acting on a single air bubble were investigated by Dijkstra zen, 2005.

The rough surface condition of the diffuser will influence the surface energy, due to decreased bubble pull out forces (F_{pa} and F_{p}). These acting forces will change slightly when the position of diffuser hole is not on the flat surface, eventually increasing the size of bubble.

![Diagram of forces acting on a growing bubble](image1)  

Figure 1. The forces acting on a growing bubble, at different pore situations.

For the drag force as stated in Table 1, the drag coefficient (CD) is 24/Re when the Re is close to 1. For the value of Re between 1 to 500, Rivikind and Ryskind suggested the following equation representing the CD as cited by Xu H., 2004:

$$CD = \frac{1}{\kappa+1}\left[\kappa\left(\frac{24}{Re} + \frac{4}{Re^{1/5}} + \frac{14.9}{Re^{0.78}}\right)\right]$$  

Where: \( \kappa = \frac{\mu_e}{\mu_i} \approx 1.831 \times 10^{-2} \) and 0.8899

As K depends on air and water viscosities therefore, the CD equation becomes:

$$CD = \frac{0.484}{Re} + \frac{0.081}{Re^{1/3}} + \frac{14.6}{Re^{0.78}}$$  

By assuming upward forces as positive and downward as negative, the balance on the free bubble is:

$$\sum F = F_B - F_D$$  

C. Experimental Set-up

Fig. 2 shows the experimental set-up to produce air bubbles through a submerged diffuser at the base of a water column. Various transducers are shown to monitor different parameters at the inlet. A vertical water column of 100 mm W x 100 mm L x 340 mm H was used. Porous sintered glass with porosities of 0 to 16 μm, and 16 to 40 μm were used to produce small size bubbles.

Compressed air at a pressure range of 5 to 33 kPa was forced through the diffuser at the base of the water column. An adjustable valve was used to control air flow in the system with a range of 0.25 to 1.8 l/min.

![Diagram of experimental set-up](image2)  

Figure 2. Schematic diagram of the experimental set-up to produce bubbles in a vertical water column.

The Laser Doppler Anemometry (LDA) was used to monitor the size of the air bubbles and their horizontal/vertical velocities. The refraction of light (when light met bubbles) was accepted by a receiver and detected as a burst, was shown on a monitor. Each burst was detected and noted as a sample. The number of samples was 1 up to 2000 and the data sampling duration was recorded in 30 seconds. The print out of LDA contains 3 bar graphs; top bar graphs representing vertical velocity, middle bar graphs representing horizontal velocity, and bottom bar graphs representing bubble diameter. Several experiments were carried out to investigate the behaviour of air bubbles in distilled water, ordinary tap water, and polluted water. A diffuser was mounted at the base side of the water column. Sintered glasses with various porosities (1-10μm, 10-16μm and 16-40μm) were used as diffusers to produce micron size air bubbles. Pressurized air was introduced through the diffuser. The bubble diameter and rise-up velocity was measured using LDA, where the laser beam refraction was captured as an input signal. The transparency of water was necessary to forward the laser refraction beam to the signal receiver. In order to maintain the transparency of the
water solution, but at the same time to have the physicochemical characteristics as close as possible to the local resident waste water. Glycerin was added to represent the pollutant.

IV. Results and Discussions
A. LDA graph result
Monodispersed bubble is a single bubble that is detected at the intersection point of the laser beams. Fig. 3 shows the print outs of the LDA showing bubble size, and horizontal and vertical velocity components of a monodispersed air bubble at an inlet air pressure of 22 kPA, using 1-10 µm sintered glass diffuser. An increase in the inlet air pressure would produce polydispersed bubbles (various diameters at the same time) as shown in Fig. 4.

The LDA print out in Fig. 3 shows a bubble of 43 µm diameter, with detection time of 30 seconds and one bubble in the vertical axis was detected. The bubbles have 0.1 m/s horizontal velocity. Fig. (4c) shows the LDA print out indicating bubbles of four different diameters (20, 25, 45, and 48 µm) had been detected. The LDA also measured different rise-up velocities for those bubbles. This shows that the velocity of each bubble cannot be easily determined in the polydispersed graph than the monodispersed case.

![LDA graph result](image)

Figure 3. LDA print outs for monodispersed bubble monitored at 22 kPA using 1-10 µm porosity sintered glass.

B. Characteristics of impurities water
Glycerine in concentrations ranging from 0.1 to 0.5 %vol was added to distilled water to represent the pollutant. At 0.4% vol. of glycerine, the artificially polluted water exhibited similar characteristics as the resident waste water. The physical characteristics of the artificial polluted water are shown in Fig. 5. Generally, surface tension decreases, whereas water density increases as the percentage of glycerine increases. The decreasing surface tension contributed to the increase of buoyancy force and drag force; the higher buoyancy force is the most wanted parameter for separation of suspended particles. Because of widening density gap between air and water, the horizontal bubble velocity also increases, creating undesired stirring effect. From these phenomena, it is obvious that the glycerine impurity does not only reduce the linearity of bubble movement and creates new horizontal velocities, but also produces variations in bubble size, as detected from bubble dispersion.

![Effect of Glycerine on various parameters](image)

Figure 5. The effect of Glycerine as an impurity on various parameters.

The air bubble diameter produced by the sintered glass depends mainly on the porosity and supplied air (pressure and flow). Smaller porosity and low inlet air pressure produce uniform micro bubbles. The larger porosity produces polydispersed bubbles i.e. a bubble with various diameters, with components of horizontal and vertical velocities. By limiting the inlet air pressure and using small porosity sintered glass, the size and velocity of bubbles can be controlled in a narrow range.

C. The influence of pollutant on bubble diameter and upward velocity
The addition of pollutant in distilled water increases the bubble size in the same way as air inlet pressure, due to increasing viscosity and decreasing surface tension. The increase in liquid viscosity causes a reduction of drag force as follow by decreasing of $\chi$ and $CD$ in equation 10, whereas the bubble diameter increases. Therefore the bubble area and volume would be larger, finally the drag and buoyancy force would be elevated. A second order
polynomial curve fit has been used to establish the relationship between inlet air pressure and bubble diameter for varying percentage of glycerine distilled water as shown in Fig. 6.

The addition of pollutant in distilled water also increases bubble upward velocity due to decreasing water surface tension. As stated in equations 2 and 6, the bubble generation forces would be increased as the decreasing surface tension decreases. The relationship between upward velocity and bubble diameter at various percentage of glycerine is shown in Fig. 7.

**Figure 6.** The relationship between inlet air pressure versus bubble diameter.

**Figure 7.** The relationship between inlet air pressure vs bubble vertical velocity.

**D. Flow characteristic in Froude and Reynolds number**

Since the bubble movement is dependent on the dynamics as well as gravitational forces acting on it, and the relationship between these forces lead to Froude number, therefore the Froude number is presented and plotted in Fig.8. The presence of pollutant in water would change the bubble diameter and velocity, consequently Froude number would be shifted to a lower value.

**Figure 8.** The relationship between velocity versus Froude number. The y error bar is in the range of 0.01 to 0.02.

Acknowledging the significance of bubble diameter as the main factor for determining Reynolds number, the relationship between Reynolds number and bubble diameter is presented and plotted in Fig. 9. From the figure, it is observed that increasing percentage of pollutant would increase the Reynolds number.

Increasing the inlet air pressure tend to generate bigger bubble and higher vertical velocity, and merging between bubbles happen more frequently due to shorter vertical distance between them. The change in bubble diameter is controlled by the inlet air pressure. This can be observed in Fig. 6, where a 9 kPa increment (from 21 to 30 kPa) produced a 5 fold increase in the average bubble size. The vertical velocity increased 8 fold (0.1 to 0.8m/s) (Fig.8.), and the Reynolds number increased 5.7 times (from 10.8 to 61.4) as indicated in Fig. 9. These show that in order to control the Reynolds number, one needs to control the bubble size, due to the strong relationship between bubble diameter and Reynolds number.

By keeping the bubble size and its upward velocity constant, the lifting of suspended particle can be achieved at the optimum condition, which has been validated by decreasing pollutant level (Fig. 10).

**Figure 9.** The relationship between Reynolds number versus bubble diameter. The y error bar is in between 2 and 3.

**E. The reduction in pollutant level**

The relationship of pollutant level versus aeration time is shown in Fig. 10, for various air bubble sizes. It is evident that the bubbles become less effectiveness to remove pollution as the bubble size increases. Smaller bubble sizes are more effective in reducing the pollutant level in water. This is clearly
shown in Fig. 10 where micro bubbles have the capacity to reduce the pollutant level from 2400 to 1200 PPM after 5 hours of aeration, whereas millimeter bubbles can only reduce the pollutant level from 2400 to 1800 PPM, after 3.5 hours.

![Image of Fig. 10. The relationship between pollutant reduction (PPM) and bubble size.](image)

V. CONCLUSIONS

Monodispersed air bubbles are released at an inlet air pressure of 22 kPa or below, whereas, a combination of monodispersed and polydispersed bubbles are produced at a pressure range of 22 kPa to 27 kPa. However, when the inlet air pressure is increased beyond 27 kPa, only polydispersed bubbles are produced, and horizontal velocity increase. These dynamic behaviours of air bubbles show that air pressure is a significant factor in controlling the generation of micro air bubble. The physical behaviours (size and velocities) of air bubble are controlled by physicochemical characteristics of water like surface tension, density, viscosity, etc.

Similarly, higher amount of glycerine in water would increase the bubble size as well as the velocity. The bubble velocity and diameter are the key factors that determine the mechanism for the suspended particle, either stirring or lifting. Millimetre sized bubbles would cause a stirring mechanism whereas micro sized bubbles would create an entrainment mechanism that would lift the suspended particles to the water surface. In general, smaller air bubbles are effective for removing smaller particles and hence reducing the pollutant level more effectively.

References


