

A SEGMENTED CAPACITANCE TOMOGRAPHY FOR VISUALISING
MATERIAL DISTRIBUTIONS IN PIPELINE CONVEYING CRUDE PALM OIL

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PTTA UTHM
PERPUSTAKAAN TUN AMINAH

*To my parents, my dearest husband and beloved children,
Omar Mohd Faizan B. Marwah, Muhammad Hafiy Darwis,
Muhammad Harris Haikal, Airis Adreana and Dhiya Amanda
for their support and understanding*



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ABSTRACT

A segmented electrical capacitance tomography (ECT) imager for palm oil process monitoring system is constructed and presented in this work. The goal of this study is to use the process monitoring system as an instrument to upkeep the local and foreign palm oil mill. This is to ensure that the monitoring of crude palm oil (CPO) in conveying pipeline during extraction of palm oil mill process flow process is efficiently controlled. The system has the capability to visualize the percentage of liquid that exist within the vessel thereore the data can be utilized to design and create better process equipment in mill process. It will also be used to control some processes in order to boost the quality of crude palm oil and the POME (Palm Oil Mill Effluent) treatment process. Most ECT in earlier research were created rapidly and utilized well in multiphase flow measurement in numerous applications such as in oil and gas industries, gas/solids cyclone, milk flows and fluidized beds. Experimentally, this work investigates the capability of using a flat in-plane segmented ECT sensor with 16 portable electrodes using two differential excitation potentials transmitted signal in order to recognize the concentration and velocity profile as well as the phase concentration of crude palm oil related multiphase systems liquid and gas. The attained concentration profile which is received from the capacitance measurements is capable to provide image of the liquid and gas mixture in the pipeline thereore, the separation process between oil and liquid waste becomes much easier and the crude palm oil's quality can be dependably monitored. The visualization results deliver information regarding the flow regime, superficial velocity and concentration distribution in two-phase flow-rate measurement system incorporating a liquid flow measuring device. The information obtained is able to help in the process equipment designing, verification of existing computational modeling and simulation techniques. It may also assist in process control and monitoring during the palm oil extraction process.

ABSTRAK

Pengime kapasitan elektrik ersegmen tomografi ECT bagi sistem paparan proses kelapa sa it telah di ina dan dipersem ahkan dalam ker a ini. Matlamat sistem ini adalah untuk digunakan se agai instrumen untuk mengekalkan kualiti minyak sa it tempatan dan asing. Ini adalah untuk memastikan aha a pemantauan penghantaran aliran proses minyak sa it mentah menerusi saluran ketika proses pengekstrakan minyak sa it dapat dika al dengan le ih e ekti . Sistem paparan ini mempunyai keupayaan untuk memaparkan peratusan cecair yang u ud dalam saluran, dengan itu data terse ut oleh digunakan untuk mereka entuk dan mencipta peralatan untuk proses yang le ih aik agi kilang pemprosesan. Ia uga oleh digunakan untuk menga al e erapa proses untuk meningkatkan kualiti minyak sa it mentah dan proses ra atan POME Palm Oil Mill Sdn E luen . Ke anyakan ECT dalam penyelidikan a al telah dicipta dengan pantas dan digunakan dengan aik agi pengukuran aliran er ilang asa dalam pel agai aplikasi seperti industri minyak dan gas, gas / pepe al siklon, aliran susu dan pepe al ter endalir. Ka ian penyelidikan ini akan menganalisa keupayaan pengesan ECT satah- erkem ar dengan 16 elektrod mudah alih dengan menggunakan dua isyarat pengu aan eza upaya yang erlainan untuk mengenalpasti konsentrasi dan pro il hala u serta konsentrasi asa minyak sa it mentah er ilang asa dengan yang ersekutu dengannya cecair dan gas . Pro il konsentrasi yang dikenal pasti daripada pengukuran menerusi sistem terse ut mampu untuk memaparkan campuran gas dalam saluran paip. Oleh itu proses pengasingan minyak erasingan dan sisa cecair men adi le ih mudah dan kualiti minyak sa it mentah oleh dipantau. Keputusan visualisasi memaparkan maklumat mengenai aliran, hala u permukaan dan ta uran konsentrasi menerusi sistem pengukuran kadar aliran dua asa yang diga ungkan dengan peranti pengukur aliran cecair. Maklumat ini dapat mem antu dalam proses mereka entuk peralatan, pengesanan pemodelan pengiraan sedia ada dan teknik simulasi. Ia uga dapat mem antu dalam ka alan proses serta pemantauan sepan ang proses perahan minyak sa it.

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LIST OF ABBREVIATIONS

°	-	degree
AC	-	Alternative-Current
ADC	-	analog to digital converter
ANOVA	-	Analysis of variance
CMOS	-	complementary metal oxide semiconductor
CpK	-	Process capability
DAC	-	digital to analog converter
DAS	-	Data acquisition system
ECT	-	Electrical Capacitance Tomography
EEPROM	-	Electrical Erasable Programmable Read Only Memory
EIT	-	Electrical Impedance Tomography
ESD	-	electrostatic discharge
ps	-	pulse per second
GUI	-	Graphical user interface
GR _R	-	Gauge of repeatability and reproducibility
Hz	-	Hertz
I/O	-	Input / Output
IDC	-	insulation displacement contact
IOCTL	-	input and output control
IPT	-	Industrial Process Tomography
ISA	-	Industry Standard Architecture
kΩ	-	kilo-ohm
kps	-	kilo-pulse per second
kHz	-	kilohertz
LBP	-	Linear Back Projection

LED	-	light emitting diode
MATLAB	-	Matrix Laboratory
Max.	-	Maximum
Mps	-	Mega bit per second
MHz	-	MegaHertz
mm	-	millimetres
MOR	-	Model Based Reconstruction
MRI	-	magnetic resonance imaging
ms	-	millisecond
MSIRT	-	Multiplicative simultaneous iterative reconstruction technique
NMR	-	Nuclear Magnetic Resonance
NMRT	-	Nuclear Magnetic Resonance Tomography
OIOR	-	Offline iteration and online reconstruction
op-amp	-	operational amplifier
PC	-	Personal Computer
PCB	-	Printed Circuit Board
PET	-	Positron Emission Tomography
PSNR	-	peak signal-to-noise ratio
PT	-	Process Tomography
PTL	-	Process Tomography Limited
RAM	-	Random Access Memory
RMSE	-	root mean square error
SNR	-	Signal to Noise Ratio
SPI	-	Serial Peripheral Interface
SW	-	Switch
USB	-	Universal Serial Bus
V_{p-p}	-	Voltage peak-to-peak

LIST OF SYMBOLS

A	-	Total gain of measurement system
A/D	-	Analog to digital
C	-	Matrix of inter-electrode capacitance
C_H	-	Capacitance measured at higher permittivity
C_L	-	Capacitance measured at lower permittivity
C_M	-	Measured capacitance
C_N	-	Normalized capacitance
C_{oil}	-	Relative capacitance of oil
C_r	-	Relative capacitance
C_{s1}	-	Stray capacitance of connecting lead
C_{s2}	-	Stray capacitance at Op-Amp feed back point
C_{water}	-	Relative capacitance of water
C_x	-	unknown standing capacitance
d	-	Distance of 2 parallel plate
D	-	Sensor diameter
ϵ	-	Effective permittivity
ϵ_0	-	Permittivity of free space
ϵ_o	-	Relative permittivity of oil
ϵ_r	-	Relative permittivity
ϵ	-	Relative permittivity of water
f	-	Frequency
$f_{unitygain}$	-	Unity gain frequency
K	-	Matrix of permittivity
K_e	-	Effective pixel permittivity
K_{en}	-	Normalized effective pixel permittivity

K_H	-	Pixel permittivity at lo er permittivity
K_L	-	Pixel permittivity at higher permittivity
L	-	Length o electrode
m	-	Num er o individual standing capacitance
M	-	Total num er o pixels
n	-	Total num er o pixels
N	-	Num er o measuring electrodes
Q	-	Unkno n matrix
S	-	Sensitivity matrix
S^{-1}	-	Inverse sensitivity matrix
SNR	-	Signal to Noise Ratio
S^T	-	Transpose sensitivity matrix
V_i	-	Input voltage
V_o	-	Output voltage
VR	-	Volume ratio
W	-	Width o electrode
x	-	Volume ratio
ΔC	-	Error capacitance matrix
ΔK	-	Error pixel matrix
ω_o	-	Corner re uency



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