HYDRAULIC MODELLING OF BAFFLE CONFIGURATION ON THE REMOVAL EFFICIENCY OF A RECTANGULAR OIL/WATER SEPARATION TANK

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by

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LIST OF ABBREVIATIONS

ADV	Acoustic Doppler Velocimeter
APHA	American public health association
API	America petroleum institute
BOD	Oxygen demand
CFD	Computational fluid dynamics
CEBL	Clear water end baffle location
CIBL	Clear water inlet baffle location
C.W.B	Clear water without inlet baffle
CIBH	Clear water inlet baffle height
CIBA	Clear water inlet baffle angle
EPA	United states Environmental Protection Agency
EU	European union
FAVOR	Fractional area volume obstacle representation
FLOSS	Flow simulator for separators
FOG	Fat, oil, and grease
GIT	Grease interceptor traps
HRT	Hydraulic retention time
LDA	Laser Doppler Anemometry
OIBL	Oil/water inlet bafflr location
O.W.B	Oil/water without inlet baffle
PDA	Phase doppler anemometry
RANS	Reynolds-averaged navier–stokes

Re	Reynolds number
RNG	Renormalization-group
SD	Standard deviation
SG	Specific gravity
SNR	Signal strength
SSOs	Sanitary sewer overflows
TSS	Total suspended solids
TLEN	Turbulent length scale
VOF	Volume of fluid

LIST OF SYMBOLS

A	Cross section area of the tank
A_d	Cross sectional area of the droplet
A_x	Area of fraction for flow in the x direction
A_z	Area of fraction for flow in the z direction
a	Acceleration of the droplet
C	Concentration of oil
C_{in}	Inlet oil concentration
C_{out}	Outlet oil concentration
$C_{(oil)}$	Concentration of oil in inlet slot
$C_{(oil)F}$	Concentration of oil in main flume
$C_{(oil)p}$	Concentration of oil in emulsion pipe
CNU	Constant parameter
C_d	Drag coefficient
$CDIS1, CDIS2, CDIS3$	Dimensionless user-adjustable parameters
$Diff$	Diffusion of dissipation
D_d	Droplet diameter
d_e	End baffle distance
d_i	Inlet baffle distance
d_{oil}	Palm oil diameter
E	Empirical roughness parameter
ε_T	Turbulent energy dissipation
F	Force balance
F_b	Buoyant force

F_g	Gravitational force
F_d	Drag force
Fr	Froude number
Fr_{in}	Froude number at the inlet slot
f	Volume fraction of the continuous phase
f_x ,f_z	Viscous accelerations
g	Gravity acceleration
G_x ,G_z	Body accelerations
G_T	Buoyancy production
H	Depth of water
H_{in}	Height of inlet opening
H_{ib}	Inlet baffle height
H_w	Height of weir
H_1	Distance from the tank bottom to the inlet opening
L	Length of oil/water separator tank
L_P	Length of the separation tank prototype
L_m	Length of the separation tank model
k	Von Kármán constant
K_T	Turbulent kinetic energy
k-ε	Kinetic energy
μ	Dynamics viscosity
m	Mass of droplet
n	Dimensional variables
p	Instantaneous total pressure
P_T	Turbulent kinetic energy production

ρ_o	Palm oil density
ρ	Fluid density
ρ_d	Density of droplet
ρ_w	Density of water
ρ_f	Constant
$\bar{\rho}$	Volume-weighted average density
Q	Flow rate
Q_F	Discharge of main flume inlet slot in separation tank
Q_p	Flow rate of oil/water emulsion injected
R_p	Average particle radius
u	Fluid velocity components in x direction
u_i	Instantaneous velocity
u_{in}	Inlet velocity
u_τ	Wall-friction velocity
u_*	Local shear velocity
u_r	Relative velocity
$\bar{u}$	Volume average velocity
V_d	Volume of droplet
V_F	Volume of fractional
V_s	Initial sample volume in liter
V_m	Velocity of the model
V_p	Velocity of prototype
v	Kinematic viscosity
v_t	Terminal velocity
v_H	Horizontal velocity

v_k	Diffusion coefficient
W	Width of the separation tank
w	Fluid velocity components in z direction
wsx	Wall shear stress in x-direction
wsz	Wall shear stress in z-direction
y^+	Dimensionless wall distances
θ	Inlet baffle installation angle
δ_{ij}	Kronecker-delta
δx	Side of fluid element in x-direction
δy	Side of fluid element in y-direction
δz	Side of fluid element in z-direction
σ_{ij}	Total stress tensor causes internal forces
γ_{ij}	Strain rate
u', v', w'	Velocity fluctuation (turbulent) in different direction
τ_w	Wall shear stress

PEMODELAN HIDRAULIK TATARAJAH SESEKAT KEATAS KECEKAPAN PENYINGKIRAN UNTUK TANGKI PEMISAHAN MINYAK/AIR

ABSTRAK

Pembuangan lemak, minyak dan gris ke dalam sistem retikulasi menyebabkan penyumbatan saluran paip dan limpahan pembentungan pembersihan. Rekabentuk tangki pemisahan minyak/air berdasarkan graviti digunakan dengan meluas di dalam unit rawatan. Pengunaan sesekat di dalam tangki pemisahan dan penilaian kesannya keatas kecekapan hidraulik adalah suatu bidang yang mencabar yang dijalankan oleh penyelidik. Kajian ini melibatkan penilaian kesan lokasi sesekat hujung, lokasi sesekat masuk, ketinggian sesekat masuk dan sudut pemasangan sesekat masuk ke atas corak aliran dan kecekapan penyingkiran tangki pemisah minyak/air menggunakan ujian makmal dan penyelakuan berangka. Meterhalaju Akustik Doppler (ADV) digunakan untuk mengukur medan halaju di dalam tangki pemisahan minyak/air di dalam makmal dengan tatarajah sesekat yang berlainan jenis untuk menentukan susuk halaju. Ujian makmal dijalankan untuk mengukur kecekapan penyingkiran tangki pemisahan minyak/air dengan berlainan tatarajah sesekat masuk. Penyelakuan berangka termasuk corak aliran dan ciri-ciri hidraulik tangki pemisahan minyak/air dengan tatarajah sesekat yang berlainan dijalankan untuk menentukan lokasi sesekat hujung dan sesekat masuk, ketinggian sesekat masuk dan sudut sesekat masuk. Hasil keputusan ujian makmal dan penyelakuan berangka menunjukan, lokasi sesekat hujung d_e/L = 0.76, lokasi sesekat masuk d_i/L = 0.12, nisbah ketinggian tenggelam sesekat masuk H_{ib}/H = 0.24, dan sudut sesekat masuk 90^o, mencapai

kecekapan penyingkiran yang maksima. Tatarajah sesekat tersebut menyebabkan isipadu zon sirkulasi dan tenaga kinetik yang minima, keseragaman susuk halaju yang tinggi, muka itu kecekapan penyingkiran yang tinggi di dalam tangki pemisahan minyak/air. Rumus untuk menentukan kecekapan penyingkiran berdasarkan lokasi sesekat masuk diperolehi daripada keputusan ujian makmal.

HYDRAULIC MODELLING OF BAFFLE CONFIGURATION ON THE REMOVAL EFFICIENCY OF A RECTANGULAR OIL/WATER SEPARATION TANK

ABSTRACT

The particular release of fat, oil, and grease (FOG) into collection systems ultimately brings about the blockage of conduits and subsequent sanitary sewer overflows. Designing oil and water rectangular separation tank due to gravitation is extensively applied in treatment units. Using baffles in separation tanks and measuring its effects on hydraulic efficiency is a challenging subject that researchers have investigated. In this study, the effects of end baffle location, inlet baffle location, inlet baffle height, and inlet baffle angle installation on the flow pattern and removal efficiency of oil/water separation tanks are investigated using experimental test and numerical simulation. The velocity field in the laboratory separation tank with various types of baffles configuration was measured by Acoustic Doppler Velocimeter (ADV) to determine the velocity profile. In addition, experimental tests are conducted to measure the removal efficiency of separation tanks equipped at different inlet baffle. Numerical simulation, including the modelling of flow pattern and hydraulic characteristics of separation tanks with different baffle configurations, was performed to determine the best end and inlet baffle location, height of inlet baffle and angle of inlet baffle. Based on the results of experimental tests and numerical models, end baffles location d_e/L=0.76, with an inlet baffle position d_i/L=0.12, inlet baffle submersible depth ratio H_{ib}/H= 0.24, and inlet baffle angle

installed at 90^0, achieve the highest removal efficiency. This configuration produced minimum circulation zone volume and kinetic energy, the most uniform velocity profiles, and thus highest removal efficiency in the separation tank. Finally a formula to determine the removal efficiency as a function of inlet baffle location is obtained from laboratory test results.