AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL POWER DEPARTMENT

STUDY OF SOLIDS DISTRIBUTION IN MIXING TANKS

A THESIS

SUBMITTED FOR THE PARTIAL FULFILLMENT OF
MASTER DEGREE IN MECHANICAL ENGINEERING

By

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To

Mum, Dad

& My Fiancée

<u>Examiner committee</u>

The undersigned certify that they have read and recommend to the Faculty of Engineering, Ain Shams University for acceptance a thesis entitled by "Study of solids distribution in mixing tanks", submitted by Yasser El-Sayed Selima, in partial fulfillment of the requirements for the degree of Master of Science in Mechanical Engineering.

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STATEMENT

This dissertation is submitted to Ain Shams University in fulfillment of the requirements for master degree in Mechanical Engineering.

This work included in the thesis was made by the author during the period from 2003 to April 2007 at Mechanical Power Engineering Department, Ain Shams University.

No part of this thesis has been submitted for degree or qualification at any other university or institute.

Date : 28/4/2007

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Abstract

Mixing tanks are used in many applications such as slurry flow, catalytic reactions, adsorption, crystallization, dissolution and many other industrial applications.

The minimum speed required for complete suspension in mixing tanks (Njs) has been extensively studied in the past. The start was by Zwietering(1958) who used visualization method to express a formula for calculating this speed. Micale et al. (2002) determined Njs by using a pressure gauge technique in a model vessel. In the present work Njs was measured by the same later technique in a more practical vessel and the results were compared to those obtained by Zwietering's correlation. Agreement was found between results from present work and predictions by Zweitring's correlation with average difference of 7% and the maximum difference did not exceed 17%.

The measurement of solids concentration distribution in mixing tanks relied on sampling technique and recently CFD (computational fluid dynamics) predictions were used. Both methods do not offer on-line results as they take a considerably long time in measurements and computations respectively. In the present work a new technique is proposed to measure the solids concentration distribution in mixing tanks using pressure measurements.

Results from the present work showed an inverse proportionality between the normalized pressure difference

(mixture pressure minus clear water pressure normalized by the value of mixture pressure) and the solids concentration in the mixing tank along the tank height. The experimental results obtained were compared with CFD predictions and good qualitative agreement was found. The technique proposed in the present work offers an on-line measurement of solids concentration distribution in mixing tanks.

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Nomenclature

A	Factor expressing the physical properties of solid particles in equation 2.33 [-]
A_b	Tank bottom area (m^2)
a	Constant used in equation 2.2 [-]
B_{js}	Ratio between velocity of the liquid at the bottom of the vessel V_B and the settling velocity of particles V_p is constant [-]
C	The impeller clearance measured from the impeller centerline to the vessel bottom (m)
C_b	The impeller clearance measured from the bottom of the impeller to the vessel bottom. (m)
C_D	Coefficient of drag force [-]
C_w	Solids concentration by weight [-]
C_v	Solids concentration by volume [-]
C_o	Initial concentration at t=0 used in equation 2.41
C_{av}	Average weight concentration in the vessel
Cv_{av}	Average volume concentration in the vessel [-]

C_{vB}	Volume concentration of solid particles deposited at the bottom, used in equation 2.34 [-]
$C_{av\ axial}$	Average axial concentration at certain radius in the tank [-]
D	Impeller diameter (m)
d_p	Diameter of solid particle (m)
d_{50}	Diameter larger than 50% of solid particles (m)
f	Constant used in equation 2.12 [-]
g	Gravitational acceleration (m/s^2)
H	The height of the liquid in the tank (measured from the straight cylindrical part in the present work) (m)
h	the average distance between the stirrer and the top surface of fillets used in equations 2.27 and 2.29 (m)
h_R	impeller height (m)
K	Blade thickness (m)
K`	Dimensionless parameter used in equation 2.43 [-]
M_s	Mass of suspended solids (kg)
M_{tot}	Total mass of solids (kg)
N	Impeller speed (rpm)

N_{js}	Minimum speed required for complete suspension (rpm)
N_p	Power number $Np = \frac{\hat{P}}{\rho_L N^3 D^5}$ [-]
N_{min}	the value at which suspension starts. (rpm)
N_{span}	Twice its value gives the range of N at which most of suspension takes place as can recognized at N_{ss} - N_{min} = 2 N_{span} , the value of X=0.982 (rpm)
N_{ss}	Sufficient suspension speed = N_{min} + 2 N_{span} (rpm)
P_{js}	The static pressure at the tank complete solid suspension (Pa.s)
$P_{Hydrostatic}$	Hydrostatic Pressure (pressure results from the weight of liquid column) (Pa)
P_m	Static pressure of mixture (Pa)
P_t	Total Pressure of mixture (Pa)
P_{static}	Static pressure for (Pa)
$P_{dynamic}$	Dynamic pressure (Pa)
P_w	Static pressure of Clear water (Pa)
ΔP	The increase in the static head due to solids suspension (Pa)