AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
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Effect of adding fine solid particles on the hydraulic conveying of coarse solids by inclined pipelines

A THESIS:
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STATMENT

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

The work included in this thesis was made by the author during the period from Nov 2005 to July 2009 at Mechanical Power Engineering Department, Faculty of Engineering, Ain Shams University.

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

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Abstract

The effect of varying fine percentage in the carrier fluid in the slurry was studied regards the flow variables; hydraulic gradient, delivered solids concentration and settling velocity, these variables were investigated in both horizontal and inclined pipes, also two solid mixtures were examined; the first has the same fine and coarse materials (phosphate), while the other, Talc was used as fine material and Sand as coarse material.

Inclination of pipelines results in increasing the hydraulic gradient for all fine percentages examined, where as increasing the fine percentage in the solid mixture was found to decrease the total delivered solids concentrations.

The settling velocity was influenced by varying fine percentage and by varying the inclination angle.

The two-layer model proposed by Gillies et al (1991) was used in predicting the hydraulic gradient and the delivered solids concentration in horizontal and inclined pipes, good agreement was found for the horizontal pipes.

Finally the use of the venturi meter as flow measurement device in slurry pipelines was examined.

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Nomenclature

A	cross sectional area	m^2
Ar	Archimedes number for a particle settling in the fluid	
C	volume concentration of solids	
C_c	contact load fraction	
C_{cr}	coarse particle concentration	
C_d	particle drag coefficient	
C_{dis}	discharge coefficient	
C_f	fine particle concentration	
C_{max}	maximum packing concentration of solids	
C_r	mean in-suite concentration	
C_v	delivered solid concentration	
D	mean particle diameter	m
D_{10}	particle diameter at 10% passing sieve	m
D_{50}	particle diameter at 50% passing sieve	m
D_{90}	particle diameter at 90% passing sieve	m
Δ_D	Durand number	
D	pipe diameter	m
F	friction factor	
F_n	normal force/unite length	N/m
F_L	Durand coefficient in equation (2.3)	
g	gravitational acceleration	m/s^2
ΔH	water head loss through the pipe line length L	m of water
I	pressure head gradient (meter of liquid/meter of pipe)	
K	Von Karmen constant	
K_o	Von Karman constant for pure water	
N_w	force due to weight of solid	N
N_Φ	force due to shear on interface	N
Q	volume flow rate	m^3/s
P	pressure	Pa
P	power	kW
Re	Reynolds number	
Re_n	Reynolds number defined by Metzener and Reed (1959) in equation 2.38	
Re_{OT}	Reynolds number defined by Oroskar and Turian (1980) in equation 2.5	
Re_p	particle Reynolds number defined in equation 2.29	
S	relative density (solids density/carrier fluid density)	
S	Perimeter	m
V	mean flow velocity	m/s
V_c	critical deposit velocity	m/s

V_s	hindered settling velocity	m/s
V_u	minimum flow velocity for suspension of solid particles	m/s
V_∞	terminal deposit velocity for particles	m/s
X	constant for fraction of eddies with velocities exceeding the hindered particle settling velocity in equation 2.4	
Y	vertical distance	m
y_b	bed height	m

Greek letters

σ	constant in equation 2.18	
β	constant in equation 2.18	
γ	constant in equation 2.18	
δ	constant in equation 2.18	
ε	diffusivity coefficient for solid particles in fluid	
ρ	Density	kg/m^3
μ	Viscosity	Pa.s
$\tau_{x,y}$	shear stress	N/m^2
η	Efficiency	
θ	bed angle	
Φ	angle of internal friction	
б	shear rate	1/sec
ζ	specific gravity	
é	Specific weight of water	N/m^3

subscripts

1	upper layer (two-layer model)
2	lower layer (two layer model)
12	interface
f	Fines
l	carrier fluid
m	slurry (solid/liquid)
s	solids
w	wall
u	up
d	down
i	input
o	output

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