REVERSE FLOW CYCLONES FOR COLLECTION OF TEA DUST

M.Sc (Chemical and Process Engineering)

I.M.B.M. De Silva

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By

I.M.B.M. De Silva

This Thesis was submitted to the Department of Chemical and Process Engineering of the University of Moratuwa in partial fulfillment of the Degree of Master of Science in Chemical and Process Engineering

Department of Chemical and Process Engineering
University of Moratuwa
Sri Lanka

July, 2003

DECLARATION

"I certify that this thesis does not in corporate without acknowledgement any material previously submitted for a degree or diploma in any University to the best of my knowledge and belief it does not contain any material previously published, written or orally communicated by another person except where due reference is made in the text."

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Supervisor
(Dr. B.M.W.P.K. Amarasinghe)

ABSTRACT

Reverse flow cyclones are used most extensively in the chemical process industries for gas – solid separation. Cyclones are often employed to collect large particles (>5μm) that can be used not only as an air pollution control device, but also for recover particulate matter and size separation of particles. Common features found in locally designed cyclones are ineffective and crudely designed. Design of cyclone is more towards realizing a shape of the cyclone than the performance. Customized design approach gives a cyclone with greater collection efficiency, smaller in size or with lower pressure drop that would be found for a conventional standard design. Since the customized design procedure requires trial and error calculations, this research focused on the importance of the development of a computer package: "CycDesign".

Using this package, a pilot scale reverse flow cyclone is designed and fabricated. This unit was used to examine the suitability of abating the air pollution caused due to dust generated from the fluidized bed dryers in tea industries. Trials were also done for sawdust, cement, quarry dust, talc powder and silica sand. Inlet and outlet particle size distributions were measured. Above 90% Overall collection efficiencies were attained for all the types of dust tested. For tea dust 99.2% collected experimentally which was predicted as 100% by the computer package. Also the computer package can be used to predict performance and dimensionless parameters for a cyclone design. It predicts that a continual decrease of Stokes number based on cut diameter, with increasing Reynolds number *Re*, for cyclones having different height to diameter ratio *H/D*. According to predictions, collection efficiency increases with *H/D* ratio of the cyclone. The declining patterns of fractional efficiency can be visualized with decreasing pressure drop across the cyclone and particle density. A decrease in fractional efficiency can be observed with the increasing of gas flow rate, gas temperature, and gas density.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to my supervisor Dr. (Mrs.) B. M. W. P. K. Amarasinghe, Head of the Department of Chemical and Process Engineering, University of Moratuwa for her great encouragement, guidance, dedication, patience paid through out the research.

My heartiest gratitude is due to Dr. Ajith de Alwis, Mr. S. A. S. Perera for their expert comments, suggestions, recommendations and motivation for research work other than being the members of progress committee.

My special thank goes to National Science Foundation for granting me financial assistance for the research project including stipend of Research Assistant. And of course I should thank Prof. (Mrs.) N. Rathnayaka, Director, Post-Graduate Studies, University of Moratuwa and her staff for great support offered through out the research project.

I would like to thank Dr. Ziad Mohammad, Director, Tea Research Institute, for giving me the valuable opportunity to visit and study the process at St. Coombs Tea factory, Thalawakelle, and all the staff at the factory.

I also would like to thank Mr. K. Jeyagoban and Mr. G. N. Wijesekara who were very helpful in developing the computer package "CycDesign". My great appreciation is also due to Mr. K. Udayarathne, Engineer, Alloy Fabrication Ltd., Ratmalana for the fabrication of main body of Reverse flow cyclone pilot unit, Mr. Kodithuwakku of S. D. Engineers, Panadura, manufacturer of air blower and Mr. C. U. Fonseka for the manufacturing of all other miscellaneous parts and involving the installation of the cyclone pilot unit.

My special Thanks are due to Mr. N. L. Chandrasiri, Unit Operations Laboratory, and all other members of technical staff at Department of Chemical and Process Engineering, University of Moratuwa.

I wish to thank Mr. S. Jayathilake and his staff at Industrial Technology Institute for the measurements of Laser beam particle size distribution analysis. Dr. O. K. Dissanayake, Head, Department of Earth Resource engineering, University of Moratuwa for providing necessary equipments for the measuring purposes. And also I am grateful Dr. T. Sugathapala, Department of Mechanical Engineering, University of Moratuwa for his valuable comments on the subject.

Also I would like to mention the service rendered by the library staff, University of Moratuwa – Ms. R. Kodikara, Librarian, Ms. Wanigasekara and all the library staff members.

I am thankful to the academic staff of Department of Chemical and Process Engineering, University of Moratuwa specially Mr. S. Wijesinghe giving enormous help to complete my literaturary work.

As usual, the help at home base has been wonderfully generous and encouraging. Advice and great support given to me by my colleagues are excellent. Finally I offer them my heartiest gratitude.

NOMENCLATURE

ΔH	Pressure drop expressed as number of inlet velocity heads
ΔP	Pressure drop
μ	Gas viscosity
ψ	Cyclone inertia parameter
η	Efficiency
	Captured fraction
ρ_G	Gas density
ρ_p	Particle density
Stk_{50}	Stokes number based on cut diameter
$\bar{\nu}$	Escaped fraction
$\eta_{fractional}$	Fractional efficiency
$\eta_{overall}$	Overall efficiency
a	Gas entry height
A_c	Interior collecting surface of the cyclone
b	Gas entry width
B	Dust outlet diameter
C	Cyclone geometry factor
C_a	Allowable outlet dust concentration
C_i	Inlet dust concentration
C_o	Outlet dust concentration
D	Cyclone cylinder diameter
D_e	Gas outlet diameter
d	Particle diameter
d_{100}	Critical particle diameter
d_{50}	Cut particle diameter
F_c	Centrifugal force acting on particle
F_d	Drag force acting on particle
H	Cyclone overall height
h	Cyclone cylinder height
n	Vortex exponent

N	Number of turns gas makes within cyclone
n_1	Vortex exponent at gas temperature at T_1 (usually 283 K)
n_2	Vortex exponent at gas temperature at T_2 K
P	Pressure drop factor
Q	Volumetric gas flow rate
r	Radial distance from cyclone axis
Re	Reynolds number
r_w	Radial distance from cyclone axis to cyclone wall
S	Gas outlet height
t	Time
T_1	Gas temperature corresponding to vortex exponent, n_1
T_2	Gas temperature corresponding to vortex exponent, n_2
u_r	Radial component of particle velocity
u_t	Tangential component of particle velocity
v	Gas velocity
v_i	Gas inlet velocity
v_r	Radial component of gas velocity
v_t	Tangential component of gas velocity
v_{tw}	Gas tangential velocity at cyclone outer wall
w	Migration velocity of the particle
Z	Natural vortex length

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