Table of Contents

Acknowledgement i

Abstract iii

Table of Contents iv

List of Figures vi

List of Tables viii

Nomenclature ix

Chapter 1: Introduction 1

1.1 Motivation 1
1.2 Fluidized bed technology 2
1.3 Fluidized bed drying 4
1.4 Objectives of the present work 6
1.5 Outline of the thesis 6

Chapter 2: Literature Review 8

2.1 Introduction 8
2.2 Bed hydrodynamics and mass transfer behaviour 8
2.3 Effect of operating parameters on fluidized bed drying 10
2.4 Drying mechanism 12
2.5 Summary of the literature review 14

Chapter 3: Methodology 15

3.1 Introduction 15
3.2 Description of the Fluidized Bed Dryer Setup 15
3.3 Description of the Ergun's Simulation Software 18
3.4 Design of Air heater 20
3.4.1 Air heater Design 20
3.4.2 Heating Coil calculation 21

3.5 Experimental procedure 23
3.6 Summary of the chapter 23

Chapter 4: Results and Discussion 25
4.1 Ergun's Fluidization Software Results 25
4.1.1 Solid Characteristics 25
4.1.2 Grid Design 26
4.1.3 Flow Structure 27
4.1.4 Cyclone Design 27
4.1.5 Pressure Drop Calculation 28
4.1.6 Heat transfer Co-efficient Calculation 29
4.2 Experimental results 29
4.3 Validation of results 39
Chapter 5: Conclusions and scope for future work 40

Reference 41

Appendices 45

I Calculation of minimum fluidization velocity 45

II Design of distributor plate 46

III Design of cyclone separator 51

IV Calibration of Blower for air supply 54

V List of Equipment/Instruments used 55

List of Figures

Fig. 1.1	Various forms of contacting of a batch of solids by fluid	3
Fig. 2.1	Geldart classification of particles for air at ambient conditions	9
Fig. 2.2	Types of moisture	13
Fig. 2.3	Batch drying curve, constant drying condition	13
Fig. 3.1	Schematic of the fluidized bed paddy dryer Experimental setup	16
Fig. 3.2	Photograph of the fluidized bed paddy dryer Experimental setup	17
Fig. 3.3	Pitot tube connected with manometer	18
Fig. 3.4	Photographs of the designed cyclone separator	18
Fig. 3.5	Straight hole type distributor plate	18
Fig. 3.6	Photograph of glass wool insulation	18
Fig. 3.7	Schematic representation of different section of the FB	19
Fig. 3.8	Schematic Air heater design	21
Fig. 3.9	Photographs of the designed electric air heater	22
Fig. 3.10	Photographs of the blower used connected with variac for speed regulation	22
Fig. 4.1.1	Solid Characteristics of the Fluidized Bed	25
Fig. 4.1.2	Grace Diagram	26
Fig. 4.1.3	Pressure drop profile of the Grid	26
Fig. 4.1.4	Flow Structure within the BFB	27
Fig. 4.1.5	Cyclone Design curve	28
Fig. 4.1.6	Pressure Drop at different section of the FB	28
Fig. 4.1.7	Variation of HTC with Solid Volume fraction	29
Fig. 4.2.1	Drying rate curve for I= 600g, U=10.2 m/s, T=75°C, P=2 KW	30
Fig. 4.2.2	Drying rate curve for I= 600g, U=10.75 m/s, T=60°C, P=2 KW	31
Fig. 4.2.3	Drying rate curve for I= 600g, U=10.67 m/s, T=60°C, P=1.5 KW	32
Fig. 4.2.4	Drying rate curve for I= 500g, U=10.67 m/s, T=60°C, P=1.5 KW	33
Fig. 4.2.5	Drying rate curve for I= 500g, U=14 m/s, T=60°C, P=2 KW	34
Fig. 4.2.6	Drying rate curve for I= 500g, U=9.5 m/s, T=75°C, P=2 KW	35
Fig. 4.2.7	Drying rate curve for I= 400g, U=9.5 m/s, T=60°C, P=2 KW	36
Fig. 4.2.8	Drying rate curve for I=600g at different operating conditions	37
Fig. 4.2.9	Drying rate curve for I=500g at different operating conditions	37

Fig. 4.2.10 Drying rate curves for the experiments performed at different operating conditions 38

List of Tables

Table 4.1.1	HTC Obtained from the different models	29
Table 4.2.1	Moisture removed against time for I= 600g, U=10.2 m/s, T=75°C, P=2 KW	30
Table 4.2.2	Moisture removed against time for I= 600g, U=10.75 m/s, T=60°C, P=2 KW	31
Table 4.2.3	Moisture removed against time for I= 600g, U=10.67 m/s, T=60°C, P=1.5 KW	32
Table 4.2.4	Moisture removed against time for I= 500g, U=10.67 m/s, T=60°C, P=1.5 KW	33
Table 4.2.5	Moisture removed against time for I= 500g, U=14 m/s, T=60°C, P=2 KW	34
Table 4.2.6	Moisture removed against time for I= 500g, U=9.5 m/s, T=75°C, P=2 KW	35
Table 4.2.7	Moisture removed against time for I= 400g, U=9.5 m/s, T=60°C, P=2 KW	36
Table 4.3.1	Comparison of the experimental results with other researchers results	39

Nomenclature

A_b : Cross-sectional area of the bed (m^2)

C_d : Orifice discharge co-efficient

d_{or} : Orifice diameter (m)

d_p : Particle diameter (m)

ε : Voidage

ε_{mf} : Voidage at minimum fluidization

H_{mf} : Height of the bed at minimum fluidization (m)

h : Heat transfer co-efficient (W/m^2-K)

Δh : Difference in height of manometric fluid of water column (cm)

I : Bed inventory (Kg)

N_{or} : Number of orifices in the distributor

ΔP_b : Bed pressure drop (N/m^2)

ΔP_d : Distributor pressure drop (N/m^2)

t : Time required for drying (min)

T : Temperature (^oC)

U_{mf} : Minimum fluidization velocity (m/s)

U_t : Terminal Velocity (m/s)

V : Supply Voltage (volts)

ρ_g : Gas Density (Kg/m^3)