

۱*

(// // //)

Visual C++ 6.0

پاشیده

Counter-current

پاشیده

()

%

()

شماتیک

. [] [] []

%

/ m

ton/hr

ton/hr

d_p

[]

(E)

(R)

()

(F)

$^{\circ}\text{C} - ^{\circ}\text{C}$

R

$\frac{\text{m}^3}{\text{hr}}$
 $^{\circ}\text{C} - ^{\circ}\text{C}$

[]

%

) $Z=L$

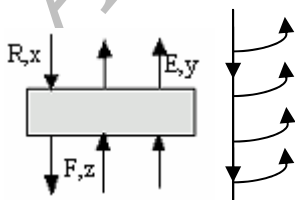
% -

()

F

()

) R



()

()

R

:() -

:() E

[]

۲- قطر

/ m

(نامیده) . []

()

(-)

dl

(-)

m/sec

/ m/sec

F R

R

FTR

FTR .

F

m

%

()

(- -)

()

[] []

$$E(1-y)|_{l+dl} - E(1-y)|_l = 0 \Rightarrow$$

$$\frac{d}{dl}(E(1-y)) = 0$$

()

: R

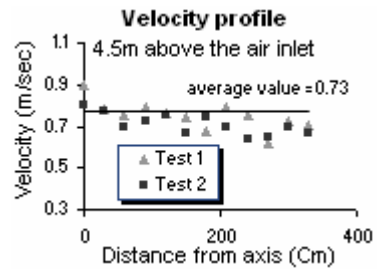
$$R(1-x)|_l - R(1-x)|_{l+dl} - FTR . dl . (1-x) = 0$$

=>

$$\frac{d}{dl}(R(1-x)) = -FTR (1-x)$$

()

F



$$F(1-z)|_{l+dl} - F(1-z)|_l + FTR \cdot dl \cdot (1-x) = 0$$

$$\Rightarrow \frac{d}{dl}(F(1-x)) = -FTR(1-x)$$

T_s و T_a ، z ، y ، x ، F ، E ، R

[]R

$$R.x|_l - R.x|_{l+dl} - FTR \cdot dl \cdot x - N_A \cdot S \cdot dl \cdot (1-\phi) \cdot a \cdot M = 0$$

$$\Rightarrow \frac{d}{dl}(R.x) = -(FTR \cdot x + N_A \cdot S \cdot (1-\phi) \cdot a \cdot M)$$

یک

N_A ، N'_A

F

h و FTR

$$F.z|_{l+dl} - F.z|_l + FTR \cdot dl \cdot x - N'_A \cdot S \cdot dl \cdot (1-\phi') \cdot a' \cdot M = 0$$

$$\Rightarrow \frac{d}{dl}(F.z) = FTR \cdot x - N'_A \cdot S \cdot (1-\phi') \cdot a' \cdot M$$

F R

FTR N_A N'_A

h

$$E.y|_{l+dl} - E.y|_l + N_A \cdot S \cdot dl \cdot (1-\phi) \cdot a \cdot M + N'_A \cdot S \cdot dl \cdot (1-\phi') \cdot a' \cdot M = 0$$

$$\Rightarrow \frac{d}{dl}(E.y) = -S.M \cdot (N_A \cdot (1-\phi) \cdot a + N'_A \cdot (1-\phi') \cdot a')$$

N'_A

N_A N'_A

N_A

h .

$$E.C_{Pa}(T_a - T_0)|_{l+dl} - (E - [N_A \cdot (1-\phi) \cdot a + N'_A \cdot (1-\phi') \cdot a'] S \cdot dl \cdot M) C_{Pa}(T_a - T_0)|_l = h \cdot S \cdot dl \cdot (1-\phi) \cdot a \cdot (T_a - T_s)$$

$$E \gg [N_A \cdot (1-\phi) \cdot a + N'_A \cdot (1-\phi') \cdot a'] \cdot S \cdot dl \cdot M$$

$$\Rightarrow \frac{d}{dl}(E.C_{Pa}(T_a - T_0)) = h \cdot S \cdot a \cdot (1-\phi) \cdot (T_a - T_s)$$

[]

N_A

N_A

($N_A = N_A|_{r=R_p}$)

$$F.C_{Ps}(T_a - T_0)|_{l+dl} - F.C_{Ps}(T_a - T_0)|_l + R.C_{Ps}(T_s - T_0)|_l - R.C_{Ps}(T_s - T_0)|_{l+dl} + E.C_{Pa}(T_a - T_0)|_{l+dl} - E.C_{Pa}(T_a - T_0)|_l = 0$$

$$\Rightarrow \frac{d}{dl}(F.C_{Ps}(T_a - T_0)) - \frac{d}{dl}(R.C_{Ps}(T_s - T_0)) + \frac{d}{dl}(E.C_{Pa}(T_a - T_0)) = 0$$

$$N_A = \frac{C \cdot D_e \cdot R_h \cdot R_p}{(R_p - R_h) r^2} (x_A^* - Y) = f(r)$$

()

$$r \frac{dN_A}{dr} = N_A \Big|_{r=R_p}$$

$$N_A \Big|_{r=R_p} = \frac{C \cdot D_e \cdot R_h}{(R_p - R_h) \cdot R_p} (x_A^* - Y)$$

()

$$\frac{T_S}{D_e} = \frac{C \cdot x_A^*}{K \cdot R_h}$$

K R_h

R_h

منظور از R_h

x R_h

$$N_A \Big|_{r=R_h} = 0$$

بیان x

$$x = \frac{m_{hp}}{m_{hp} + m_{dp}}$$

$$\Rightarrow m_{dp} = \frac{(1-x)}{x} m_{hp}$$

$$m_{dp} = \frac{(1-x)}{x} \left(\frac{4}{3} \pi \cdot R_h^3 \cdot \phi_p \cdot \rho_w \right)$$

m_{dp}

$$R_h = \sqrt[3]{m_{dp} \frac{x}{(1-x)} \times \frac{3}{4 \pi \phi_p \rho_w}}$$

$$m_{dp} = m_{p0} \times (1 - x_0)$$

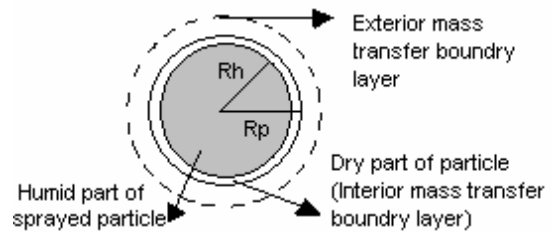
R

$$\rho_s \cdot \frac{4}{3} \pi \cdot R_p^3 = m_{p0}$$

()

[]
F R

() A



$$N_A \cdot A_r \Big|_r - N_A \cdot A_r \Big|_{r+dr} = 0$$

$$\frac{d}{dr} (4\pi r^2 \cdot N_A) = 0 \Rightarrow \frac{d}{dr} (r^2 N_A) = 0$$

$$\Rightarrow r^2 \cdot N_A = K_1$$

()

$$N_A = -C \cdot D_e \cdot \frac{dx_A}{dr}$$

$$-C \cdot D_e \cdot \frac{dx_A}{dr} = \frac{K_1}{r^2}$$

$$x_A = Y \text{ @ } r = R_p$$

$$x_A = x_A^* \text{ @ } r = R_h$$

) Y/K x_A

T_S

$$C \cdot D_e \cdot x_A = \frac{K_1}{r} + K_2$$

$$\Rightarrow K_1 = \frac{C \cdot D_e \cdot R_h \cdot R_p}{(R_h - R_p)} (Y - x_A^*)$$

()

رای سایر پارامتر های مجهول نظیر De و Nu نیز مورد استفاده قرار می گیرد.

(ρ_s)

(x_0)

$$N'_A$$

$$R_p$$

$$m_{dp}$$

$$R_p$$

()

$$x_A \quad (\quad - \quad - \quad)$$

$$z_A^* \quad x_A^*$$

$$z \quad x$$

$$z_A$$

$$D_e$$

$$R'_p \quad R_p$$

$$T_a$$

$$z_A^*$$

FTR

$$F$$

$$R$$

$$D_{AB} = a.T_S^b$$

()

$$dl$$

$$b$$

$$/$$

Knudsen

$$b$$

$$a$$

[]

$$F$$

()

$$u_t = u_{Powder} - u_{air}$$

()

$$\varepsilon_p$$

$$D_{AB}$$

$$u_t$$

[]

$$/ - /$$

$$u_t = \sqrt{\frac{4d_p \cdot (\rho_p - \rho)g}{3C_d \cdot \rho}}$$

()

برای

$$\tau$$

$$D_{AB}$$

tortuosity یا پیچ مسیراست

$$\bar{I}$$

[]

$$u_{Powder} - u_{air}$$

$$u_t = u_{Powdre} - u_{air}$$

$$g \quad C_d \quad \rho \quad (\quad)$$

$$\rho_p$$

$$D_e = \frac{D_{AB} \cdot \varepsilon_p}{\tau}$$

()

$$a$$

$$D_e = 0.13D_{AB}$$

[]

$$/$$

()

یعنی m_{dp}

$$m_{hp} \quad (\quad - \quad)$$

از داده های تجربی موجود سیستم به روش محاسبات معکوس⁵

می توان با استفاده Y و x_A K

K

$$\rho_p$$

FTR

$$\rho_p = \frac{m_p}{V_p} = \frac{m_{dp} + m_{hp}}{\frac{4}{3}\pi(d_p/2)^3} \quad ()$$

$$\frac{E \times \rho}{A_t} \quad u_{air} \quad \frac{R \times \rho_p}{A_t} \quad u_{Powder}$$

() u_t می آید ()

$$d_p \quad u_t$$

conical

می کنند

spray sheet

d_{fine}

F R

)

[]

(cp

d_{fine}

l=L

FTR

d_{fine}

FTR

:

$$l = L \xrightarrow{\text{from eq (21), (22)}} d_{fine} = f(l)$$

$$\text{Mesh } (d_{20}, d_{60}, d_{80}, d_{100}) \xrightarrow{\text{if } d_{fine}=d_i}$$

$$\text{FTR} = R \cdot P_i, \text{ otherwise: FTR} = 0$$

[]

$$D_{50} = f d^{0.2} V_p^{-0.9} \eta^{0.1} \rho^{-0.5}$$

()

d_i

P_i

P_i

که در آن D_{50} قطر متوسط، d قطر توربین، V_p سرعت محیطی، η گرانروی مایع، و ρ چگالی مایع است.

()

FTR

زیرا

F R

bar

()

()

$a' a$

()

$R' P R_P$

$N' A N_A$

bar

Mesh	20	60	80	100	200	270	325
Dia. (mm)	0.84	0.25	0.177	0.149	0.074	0.053	0.044
Per. (%)	17.36	66.92	5.72	5.4	4.3	0.25	0.009

$l=0$

تعیین

D_{AB}

b a

()

- تابعیت
رینولدز

$$Nu = 2.0 + c.Re^d$$

d c

()

[]

افشانه ای

پیش

a b c ، d به گونه ای

d c ، b a

()

()

Nu

()

به نتایج ارائه شده

()

Re

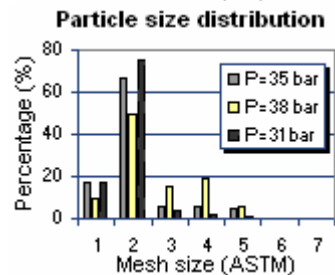
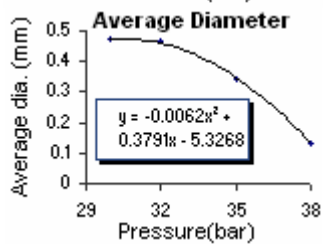
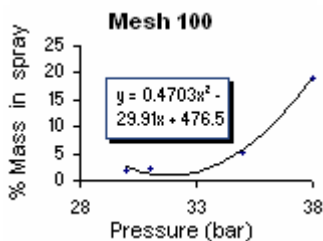
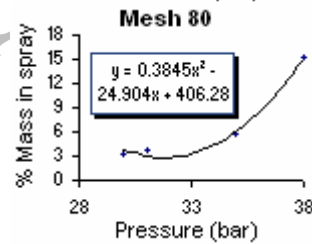
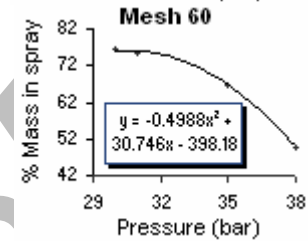
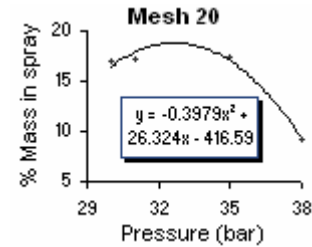
$$Nu = 2 + 1.09 Re^{0.74}$$

:

T

D_{AB}

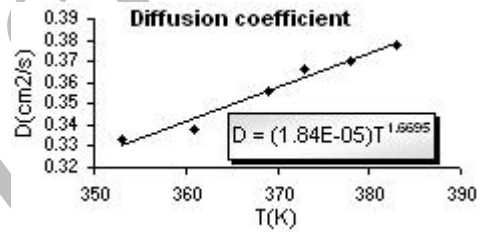
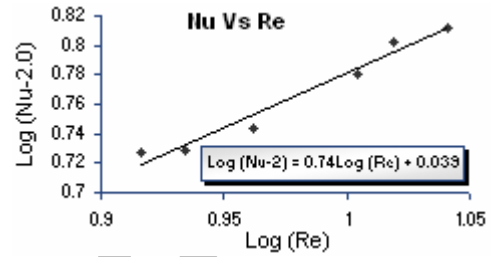
$$D_{AB} = 1.84 \times 10^{-5} T^{1.67}$$



$$K \quad T$$

$$cm^2 / sec$$

$$[] \quad []$$



()

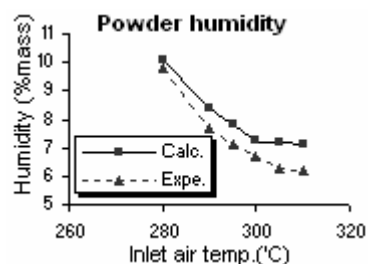
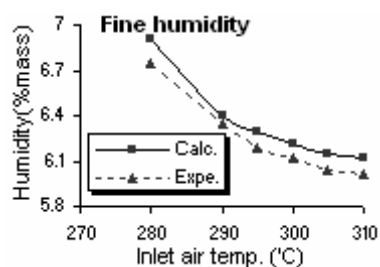
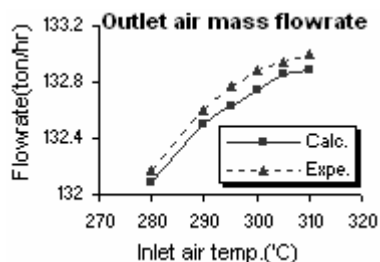
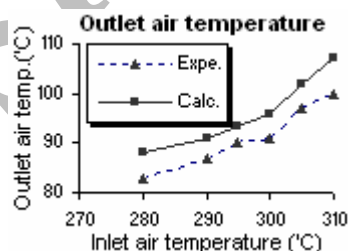
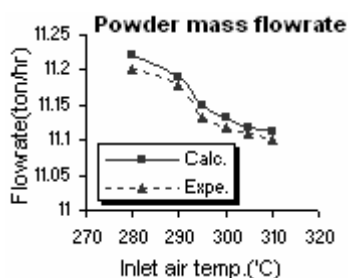
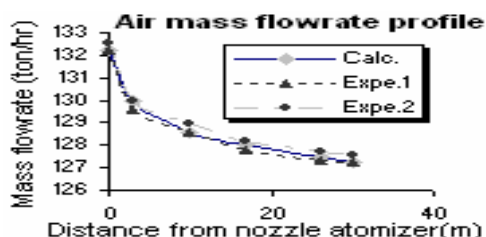
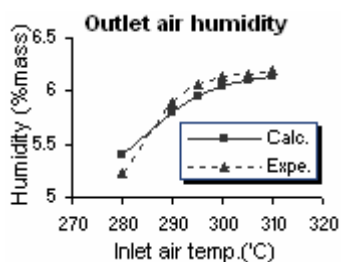
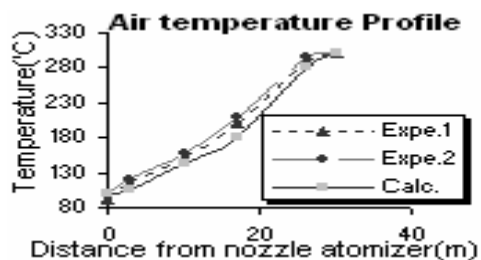
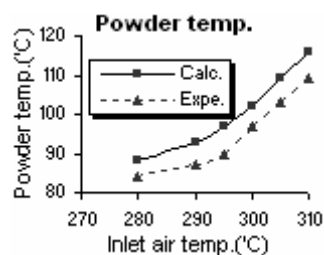
$$m_{slurry} = 18000 kg/hr \quad m_{air}|_{Down} = 127250 Kg/hr$$

$$T_{Slurry} = 79 \text{ }^\circ\text{C} \quad T_a|_{down} = 300 \text{ }^\circ\text{C} \quad Z|_{Down} = 0$$

$$F|_{Down} = 0 \quad y|_{Down} = 0.011 \quad x|_{top} = 0.4$$

D_{AB} Nu

Tower location	Test	Temp. ($^\circ\text{C}$)		Humidity (mass %)			Flow rate (ton/hr)		
		air	slurry/powder	Air	Fine	Slurry/powder	air	slurry/powder	fine
Top	1	93	78	6.59	6.2	40	112.700	18.000	475
Down	1	297	110	1.15	-	8.5	106.500	12.540	-
Top	2	90	79	6.5	6.5	40	116.257	18.000	520
Down	2	295	108	1.21	-	8.1	110.000	12.480	-
Top	3	101	78	6.66	6	40	114.300	18.000	490
Down	3	306	114	1.15	-	7.1	108.000	12.500	-
Top	4	92	75	6.13	6.2	40	118.230	18.000	540
Down	4	290	104	1.2	-	8.3	112.000	11.225	-
Top	5	82	72	6.24	6.9	40	115.100	18.000	500
Down	5	272	98	0.99	-	9.3	109.000	11.390	-



میزان تطابق نتایج محاسباتی با داده های تجربی قابل قبول و همواره کمتر از ۱۰٪ می باشد که این مطابقت را می توان موید درستی مدل سازی تلقی نمود.

%

بنابراین

ذرات ریز

	$[kg/m^3]$:	ρ_P		
	$[kg/m^3]$:	ρ_S		
	$[^\circ C]$:	T_S		
	$[^\circ C]$:	T_a	FTR	
	$[J/kg \cdot ^\circ C]$:	C_{Ps}		
	$[J/kg \cdot ^\circ C]$:	C_{Pa}	(D_{AB} NU)	
	$[^\circ C]$:	T_0		
	$W/m^2 \cdot ^\circ C$:	h		
	$[m]$:	R_p		
		:	R_h		
	$[m]$ ()	:	d_{fine}		
R	$[m]$:	F		
	$[m/s]$:	u_t		
	$[m/s]$:	u_{air}		
	$[m/s]$:	u_{Powder}		
	$[m^2/s]$:	g	$[kg/hr]$: E
		:	C	$[kg/hr]$: R
		:	$[mol/m^3]$	$[kg/hr]$: F
	$[m^2/s]$:	D_{AB}		: y
		:	D_e		: Y
	$[m^2/s]$:	C_d		: x
		:	A_r		: z
		:	سطح انتقال جرم برای جزء دیفرانسیلی ذره پاشیده شده $[m^2]$: N_A
	$[kg]$:	m_{hp}		: N'_A
	$[kg]$:	m_{dp}		: $[mol/m^2 \cdot hr]$
		:	m_{p0}	$[m^2]$: S
		:	x_A		: a
		:	x_A^*		: $[m^2/m^3]$
		:	کسر مولی اشباع در هر شعاع از درون ذره پاشیده شده		: a'
		:	K		: ϕ
		:	ضریب تعادلی در فصل مشترک رطوبت داخل ذره با رطوبت هوای محیط		: ϕ'
		:	m_p		: ϕ_P
		:	جرم ذره پاشیده شده $[kg]$: M
		:	V_p	$[kg/m^3]$: ρ_W
		:	حجم ذره پاشیده شده $[m^3]$	$[kg/m^3]$: ρ

p : چگالی مایع داخل افشانک [gr/cm ³]	()	d_i :
Nu :		[m]
Re :		P_i : درصد فراوانی هریک از اندازه مش ها
FTR :		D_{50} : قطر متوسط [mm]
[kg/m.hr]		d : قطر توربین [mm]
		V_p : سرعت محیطی [cm/s]
		η : گرانروی مایع داخل افشانکهای پاشش [gr/cm.s]

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|----------------------|-----------------------|-------------------------|-----------------|
| 1 - Co-Current | 2 - Plug Flow | 3 - Fines Transfer Rate | 4 - Correlation |
| 5 - Back Calculation | 6 - Terminal velocity | 7 - Retarding Force | |